Explaining latrine cleanliness: habitual latrine cleaning, psychosocial factors, contextual factors and general hygiene practice

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Abstract

Latrine cleanliness is important to ensure the beneficial effects of access to sanitation on health and well-being. Behavior change interventions may be necessary to enhance the regular cleaning of facilities and therefore it is necessary to understand what influences cleanliness. Three empirical studies were conducted in rural Burundi to find contextual and psychosocial factors influencing latrine cleanliness, to plan and evaluate an intervention based on these findings, and to understand how general hygiene practice influences latrine cleanliness.

Overall, the results emphasize the importance of psychosocial and contextual factors for latrine cleanliness. It makes sense to promote behavior change, as habitual latrine cleaning was the most important predictor of latrine cleanliness. Latrine cleanliness was also related to characteristics of the quality of latrine construction and encouraging households to improve the quality of their latrines could further enhance cleanliness. Psychosocial factors, especially commitment strength and positive emotions towards cleaning, and satisfaction with latrine cleanliness were important predictors for habitual latrine cleaning and should therefore be targeted by behavior change promotions. Moreover, the results for general hygiene practice suggest that it is important to examine latrine cleanliness not in isolation but within the broader perspective of general hygiene as all kind of different hygiene behaviors were interrelated.

Die Sauberkeit von Latrinen ist wichtig, um die positiven Auswirkungen von sanitären Einrichtungen auf Gesundheit und Wohlbefinden zu gewährleisten. Damit Latrinen regelmässig geputzt werden, können Kampagnen zur Verhaltensänderung notwendig sein. Dafür ist es wichtig zu verstehen, wieso Latrinen sauber sind oder nicht. Drei empirische Studien aus dem ländlichen Burundi untersuchen kontextuelle und psychosoziale Faktoren, welche die Sauberkeit von Latrinen beeinflussen. Die Studien evaluieren eine evidenz-basierte Intervention und analysieren wie die generelle Hygienepraxis die Sauberkeit von Latrinen beeinflusst.

Insgesamt unterstreichen die Ergebnisse die Bedeutung von psychosozialen und kontextuellen Faktoren. Verhaltensänderungskampagnen sind sinnvoll, da das gewohnheitsmässige Putzen der Latrine der wichtigste Prädiktor für deren Sauberkeit war. Im Weiteren beeinflusste die Qualität der Bauweise der Latrine das Putzverhalten und könnte für Verhaltensänderungskampagnen mitberücksichtigt werden. Psychosoziale Faktoren, insbesondere die Stärke des Commitments, positive Emotionen und Zufriedenheit mit der Sauberkeit, beeinflussten das gewohnheitsmässige Putzen stark und sollten durch Verhaltensänderungskampagnen in den Fokus genommen werden. Zudem zeigen die Ergebnisse bezüglich genereller Hygienepraxis, dass die Sauberkeit von Latrinen unter der Perspektive von Hygiene allgemein angeschaut werden sollte, da die verschiedenen Hygieneverhalten miteinander verbunden waren.

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Contents

Abbreviations

ANOVA	Repeated-measures Analysis of Variance
CFI	Comparative Fit Index
HI23	Hygiene Inventory (Stevenson et al., 2009)
JMP	WHO/UNICEF Joint Monitoring Program
RANAS	Risk, Attitudes, Norms, Abilities and Self-Regulation Model (Mosler, 2012)
RMSEA	Root Mean Square Error of Approximation
SD	Standard Deviation
UNICEF	United Nations Children's Fund
WaSH	Water, Sanitation and Hygiene
WHO	World Health Organization

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Chapter I

General introduction

1. Overview

Latrine cleanliness is vital for health and for well-being. This dissertation focusses on its determinants to enable evidence-based interventions to improve latrine cleanliness. It looks at how habitual latrine cleaning, psychosocial factors, contextual factors, and general hygiene practice can be useful in explaining latrine cleanliness.

The introduction is divided into five sections. The first is about the significance of access to sanitation and latrine cleanliness for health and well-being in general. The second presents research on contextual and psychosocial factors associated with access to sanitation and latrine cleanliness and points out that the research into influences on latrine cleanliness is still quite thin, especially for rural areas. The third section addresses the issue of behavior change and brings in theoretical background. Social-cognitive behavior change theories and theories developed specifically for changing health behavior in developing countries are presented and, at the end of the section, a new framework is introduced to explain latrine cleanliness. The fourth section looks at habitual latrine cleaning and latrine cleanliness in the broader context of hygiene and proposes to extend the framework of latrine cleanliness by taking general hygiene practice into account. The fifth and last section recapitulates the research questions of this dissertation.

2. Significance of access to sanitation and latrine cleanliness

"To achieve access to adequate and equitable sanitation and hygiene for all by 2030," is one of the 17 sustainable development goals (UN General Assembly, 2015). Those goals are the new commitments of the international community towards worldwide development and follow the period of 1990 to 2015 of the millennium development goals. There is quite a way to go, as in 2015, it was estimated that 32 per cent of the world's population or 2.4 billion people still lacked access to improved sanitation facilities (Unicef and World Health Organization, 2015). *Improved sanitation* as it was defined by the millennium development goals, is according to the sustainable development goals now only regarded as *basic sanitation.* Basic or improved sanitation facilities are those which separate excreta from human contact hygienically. Usually, these are pit latrines that can be classified as basic sanitation facility if it has a superstructure, and a platform or squatting slab constructed of durable material (JMP, 2015). In addition to basic sanitation, the sustainable development goals aim for *adequate sanitation* in regard to safe reuse and treatment of excreta. However, the new goals specify that households must reach basic sanitation before they can achieve adequate sanitation.

2.1 Sanitation and health

Sanitation is considered to have a substantial impact on global mortality and morbidity mostly because of its effect on diarrhea. In most cases, diarrhea is a water-borne disease caused by pathogens ingested over the fecal-oral route (World Health Organization, 2014). Thanks to sanitation, the fecal-oral route can be interrupted. Feces cannot be washed into drinking water, they do not mix with crops (which can happen by going open in the field) and, depending on the sanitation facilities, flies cannot access the feces (Reed & Shaw, 2012; Waddington & Snilstveit, 2009). Globally, diarrhea is still one of the leading causes of mortality, mostly in Southeast Asia and Sub-Saharan Africa. The most recent estimate puts the 2012 total at 842 000 diarrhea deaths globally, 43 per cent of which were children under the age of five (Prüss-Ustün et al., 2014). Still, not all of these deaths were caused by inadequate sanitation alone, but the cluster of inadequate water, sanitation and hygiene (WaSH) is estimated to be responsible for nearly 60 per cent of diarrheal diseases (Prüss-Ustün et al., 2014). Recent analysis estimates that inadequate sanitation alone was responsible for 280 000 diarrhea-related deaths in children and adults in 2012 (Prüss-Ustün et al., 2014).

However, it should be noted that these are estimates that come with an uncertainty, especially as there are not many studies of high quality that analyze the impact of sanitation on diarrhea.

In their reviews, Cairncross et al. (2010) and Clasen et al. (2010) both mention that there is very little rigorous evidence for the impact of sanitation on diarrhea, and Wolf et al. (2014) who conducted the most recent meta-analysis on the impact of improved sanitation on diarrhea found only 11 studies they could include. Regardless of that, Clasen et al. (2010) concluded that sanitation has a beneficial effect on diarrhea and Cairncross et al. (2010) and Wolf et al. (2014) provide estimates for diarrhea reduction. Cairncross et al. (2010) estimate that improved sanitation comes with a 36 per cent diarrhea reduction, and Wolf et al. (2014) estimate a 28 per cent risk reduction for improved over unimproved sanitation on diarrhea.

Apart from diarrhea, inadequate sanitation has also been linked to helminth infections (see meta-analyses of Strunz et al., 2014 and Ziegelbauer et al., 2012) schistosomiasis (see meta-analysis of Grimes et al., 2014), and trachoma (see meta-analysis of Stocks et al., 2014). Again, all of these authors note that the quality of the studies included in their analysis was mostly low. Sanitation has moreover been linked to stunting (see review of Cumming & Cairncross, 2016; Spears, 2013; and Sinharoy et al., 2016). Sanitation influences stunting through several mechanisms. During episodes of diarrhea or helminth infections, food uptake is lower. In addition, poor sanitation can lead to a subclinical condition referred to as environmental enteric dysfunction which causes a reduced absorptive capacity of the digestive system (Crane, Jones, & Berkley, 2015).

A problem that intervention studies on sanitation face quite often is that health effects of sanitation interventions remain uncertain because of low adherence with the intervention. Even if they target whole communities this does not mean that the whole community will adhere to the intervention. It might be that only parts of the households in communities build latrines or that even if they build them they do not use them consistently. Table 1 displays results of four recent cluster-randomized intervention studies on diarrhea and other diseases. None of them found an effect of their intervention on diarrhea. The only effect on health found was in the study by Pickering et al. (2015) who evaluated a community led total sanitation program in Mali. They found no effects on diarrhea but an effect on stunting and child growth. However, it is not surprising that the other studies found no effects on health: the effects they had on latrine coverage and use were rather moderate. Clasen et al. (2014) report an impressive increase of latrine coverage but their use remains quite low. The authors discuss that no health gains can be expected if parts of the community do not adhere to the intervention because then fecal contamination will probably remain high. In line with this thought, a recent study in India shows, that an increase in latrine coverage does not necessarily lead to a reduction in human

fecal pathogens (Odagiri et al., 2016). The authors believe that the lack of reduction was due to inconsistent use of latrines. So although the studies displayed in Table 1 were large-scale studies of very good quality, they could not be used to estimate the impact of improved sanitation on diarrhea.

In conclusion, there is evidence of health gains brought by sanitation, but it is based on relatively few studies often of low quality. Sanitation intervention studies often find no or very little health gains only because of low adherence to the intervention. The most established health gain of sanitation is the one on diarrhea. Not only because it is best studied, but also because of the assumption that sanitation facilities can act as barriers to interrupt the fecal-oral route.

Table 1. Cluster-randomized sanitation intervention studies

Author & Year	Kind of intervention	Country	N	Outcomes	Effectiveness
Patil et al. (2014)	Total sanitation campaign	India	5209 children under 5 years old; 3039 households;	Diarrhea	No effect
				Growth	No effect
				Highly credible gastrointestinal illness	No effect
				Helminth infection	No effect
				Anemia	No effect
				Open defecation	10% decrease
				Access to improved latrines	19% increase
Amy J Pickering et al. (2015)	Community led Total Sanitation	Mali	4532 households	Child diarrhea	No effect
				Stunting	Less stunted (35% vs. 41%)
				Child growth	18% better in height for eight and 9% better in weight for age
				Access to latrine	30.2% higher in the intervention group
Huda et al. (2012)	Sanitation Hygiene Education and Water Supply project	Bangladesh	1700 households	Child diarrhea	No effect
				Child respiratory illness	No effect
				Handwashing after cleaning child's anus	Increase from 22% to 36%
				Handwashing at various other moments	No effect
				Access to latrine	Increase from 90% to 93.2%
				Latrine improvement	No effect
				Cleanliness of latrine	No effect
				Appropriate child feces disposal	No effect
Clasen et al. (2014)	Total sanitation campaign	India	9480 households	Child diarrhea	No effect
				Child helminth infections	No effect
				Child growth	No effect
				Latrine coverage	Increase from 9% to 63%
				Fecal exposure	No effect
				Used latrine	36% vs. 9% in control

Note. Studies were included if recent (after 2010) and identified with a search in pubmed with the words "sanitation" "diarrhea" and "cluster-randomized" as well as by filtering the reference list of relevant reviews.

2.2 Benefits of sanitation beyond health

The benefits of improved or adequate sanitation are not limited to health. Indeed, on the individual level health gains are rather seldom mentioned when it comes to perceived benefits of sanitation. To date there are several studies that report on individually perceived benefits of sanitation. In this section the perceived benefits most often mentioned in a set of about a dozen qualitative studies will be presented.

Strikingly, often the same benefits are mentioned across a wide range of different countries and cultures. One of them is comfort and convenience. This was the case in India (Boisson et al., 2014; Hirve et al., 2015; Sahoo et al., 2015), in Malaysia (Kiyu & Hardin, 1993), in Cambodia, Indonesia and Vietnam (Mukherjee, 2000, 2001), in Benin (Jenkins & Curtis, 2005), and Ghana (Jenkins & Scott, 2007; Rodgers, Ajono, Gyapong, Hagan, & Emerson, 2007). Reasons why latrines were perceived as convenient were that using them is more time saving than searching a place for open defecation and that they are especially convenient to use during the night or with rainfalls (Boisson et al., 2014; Hirve et al., 2015; Mukherjee, 2001; Sahoo et al., 2015). Another aspect often mentioned in relation to sanitation facilities, were prestige and status, whereas open defecation was related to indignity and shame (Boisson et al., 2014; Hirve et al., 2015; Jenkins & Curtis, 2005; Mukherjee, 2000; Russel et al., 2015; Sahoo et al., 2015). Moreover, latrines were perceived as representing the modern lifestyle (Jenkins & Curtis, 2005; Russel et al., 2015).

One more benefit of sanitation stated frequently was cleanliness, namely the cleanliness of the facility itself or the aspect that it helped to keep the environment clean (Jenkins & Scott, 2007; Kiyu & Hardin, 1993; Kwiringira, Atekyereza, Niwagaba, & Gunther, 2014; Mukherjee, 2001; O'Loughlin, Fentie, Flannery, & Emerson, 2006; Rodgers et al., 2007). A different facet often mentioned was the privacy sanitation facilities provide compared to open defecation (Diallo et al., 2007; Jenkins & Curtis, 2005; Kwiringira, Atekyereza, Niwagaba, & Gunther, 2014; Mukherjee, 2000, 2001; O'Loughlin et al., 2006). This was relevant especially to women (Boisson et al., 2014; Hirve et al., 2015; Sahoo et al., 2015). For them, latrines were also important because they associated them with safety (Jenkins & Scott, 2007; Mukherjee, 2001) whereas open defecation was related to fear from or actual harassment (Boisson et al., 2014; Hirve et al., 2015; Sahoo et al., 2015). There are many reports that owning a sanitation facility can provide safety, as women might be harassed on their way to defecate in the open (e.g. Boisson et al., 2014; Cairncross, 2003; Nallari, 2015). Very recently the first quantitative study on the subject of open defecation and violence has been published, and results showed higher

odds for women in Kenya practicing open defecation to experience non-partner violence (Winter & Barchi, 2016). Improved sanitation facilities are also safer than unimproved ones as they are less likely to collapse and therefore safer and easier to use, especially for children (Hutton & Chase, 2016).

The perceived benefits of sanitation last mentioned, namely privacy and safety, have a strong gender aspect. In general, access to sanitation is believed to strengthen gender equality (Hutton & Chase, 2016). Not only because of the aspects mentioned but also because it is often stated that sanitation facilities are important for girls as it is believed that they can reduce school absenteeism. However, there is only one cluster-randomized trial on this topic: In Kenya, absenteeism among girls was reduced through a hygiene, water and sanitation intervention, though the sanitation component brought no further reduction compared to the hygiene and water component alone (Freeman et al., 2012).

In line with all of the mentioned perceived benefits, sanitation is also seen as a question of dignity, and is actually a human right (Chambers & Kar, 2008; Hutton & Chase, 2016; UN General Assembly, 2010). Qualitative research from Nepalese villages suggests an increase in civic pride after the people in the villages stopped defecating in the open (McMichael & Robinson, 2016). On the other hand, in Kenya lack of sanitation made people feel marginalized as it was revealed by key informant interviews and focus groups (Bisung & Elliott, 2016).

In addition to the mentioned benefits of sanitation, sanitation does also impact the economy. If people fall sick due to inadequate sanitation, this creates costs for health care, productivity losses and costs due to premature mortality. In their review, Hutton and Chase (2016) find estimates of losses caused between one and seven per cent in gross domestic products.

2.3 Sanitation facilities and latrine cleanliness

The cleanliness of sanitation facilities is pertinent because it is an important perceived feature of sanitation facilities (e.g. Jackson, 2004; Sara & Graham, 2014). It influences the actual use of the facilities and is assumed to influence health. In a study in informal settlements of Kampala, Tumwebaze, Orach, Niwagaba, Luthi, and Mosler (2013) showed that low cleanliness can lead to dissatisfaction among latrine users. It can also cause the users to go back to open defection (see Kwiringira, Atekyereza, Niwagaba, & Günther, 2014 for a study in Kampala; McFarlane, 2008 for a study in Mumbai) or negatively influence the consistency with which latrines are used (Yimam, Gelaye, & Chercos, 2014). Qualitative research in Kenyan schools showed that pupils urinate and defecate in the open if latrines are too dirty. This

behavior was carried out despite the fact latrines were present on school premises and even if pupils preferred to use them because of privacy reasons and to set a good example for younger pupils (Caruso, Dreibelbis, Ogutu, & Rheingans, 2014). Interestingly, school latrine cleanliness was the only factor related to WaSH that was associated with reduced odds of absence in a cross-sectional analysis in schools in Kenya (Dreibelbis, Greene, et al., 2013).

Further, the cleanliness of sanitation facilities is relevant because unclean facilities are believed to constitute a health hazard (Sijbesma, 2008). However, the research base for this assumption is very weak. A study, conducted almost forty years ago in Colombia, found that unhygienic conditions in school toilets were related to diarrhea (Koopman, 1978). Contrarily, a recent cross-sectional study in Rwanda showed no association between cleanliness of sanitation facility and stunting or child diarrhea (Sinharoy et al., 2016).

In this section, I elaborated on the importance of sanitation facilities and their cleanliness for health, especially diarrheal diseases. I further illustrated the personal and subjective significance of sanitation regarding dignity, comfort, privacy and safety. Lastly, I emphasized the role of latrine cleanliness as important perceived feature of latrines, that affect their actual use. To better understand latrine cleanliness for eventually planning and implementing promotions to improve it, it is fundamental to know its determinants. Consequently, this dissertation aims to understand factors associated with latrine cleanliness and the habitual latrine cleaning through a study of households in rural Burundi.

3. Factors associated with access to sanitation and latrine cleanliness

The challenge to meet the sustainable development goal for sanitation is enormous. Lately it has been acknowledged that it is almost impossible to solve the problem with public funds alone and that just providing facilities is not sustainable and there should be a shift from supply driven provision of facilities to demand-oriented approaches and to sanitation promotion (Jenkins & Sugden, 2006; Mehta & Knapp, 2004). In order to plan promotions, it is important to understand what drives and influences people to have sanitation facilities and to maintain them properly, thus to know factors that are associated with access to sanitation and latrine cleanliness. In the two sub-sections to follow, research on the contextual and psychosocial factors associated to access to sanitation and latrine cleanliness will be presented.

3.1 Contextual factors and access to sanitation

There are many contextual factors influencing access to sanitation positively, but three are predominant. These are living in an urban area, having a higher income and better education. Research on the contextual factors influencing latrine cleanliness is less abundant and it mainly focusses on how number of users and quality of latrine construction influence its cleanliness.

Worldwide, but especially in low- and middle-income countries, access to sanitation is higher in urban than in rural communities. The Joint Monitoring Program (JMP) of the United Nations Children's Fund (Unicef) and the World Health Organization (WHO) estimated that in 2015 whilst urban coverage with improved sanitation was 82 per cent, rural coverage was only 51 per cent (Unicef and WHO, 2015). The urban lifestyle does not only affect the people that live in cities but also rural people: there are reports that rural people who have spent some time in cities (e.g. for work) and used sanitation facilities there, are more likely to have or to want a sanitation facility (O'Reilly & Louis, 2014; Routray, Schmidt, Boisson, Clasen, & Jenkins, 2015) and that rural households are more likely to own latrines if they live closer to an urban center (Awoke & Muche, 2013; Jenkins & Cairncross, 2010). Apart from the vicinity of an urban center, the area of living also influences access to sanitation: fewer sanitation facilities were found in highland rural villages compared to lowland rural villages in Vietnam (Rheinländer, Samuelsen, Dalsgaard, & Konradsen, 2010). In rural areas, an additional factor was occupation, with farming households being less likely to have or to want a latrine (Jenkins & Cairncross, 2010) and to have a lower willingness to pay (Van Minh, Nguyen-Viet, Thanh,

& Yang, 2013) and livestock keeping households being less likely to have a latrine (Sara & Graham, 2014).

The JMP report also shows that coverage with improved sanitation varies widely by income depending on the country. For example, in Namibia, the richest wealth quintile has almost universal coverage in comparison to the poorest quintile with a coverage of less than 10 per cent (Unicef and World Health Organization, 2015). There are other studies linking the access to sanitation with socio-economic status. For example, richer households in informal settlements of Dar es Salaam were more likely to have access to safe, sustainable and functioning sanitation (Jenkins, Cumming, Scott, & Cairncross, 2014), and were more likely to own a latrine in Ghana (Rodgers et al., 2007) in Ethiopia (Awoke & Muche, 2013) or in urban informal settlements in Rwanda, Uganda and Kenya (Okurut & Charles, 2014). Richer households were also more likely to take up ecological sanitation in rural Uganda (Tumwebaze et al., 2011) or respond to a sanitation marketing campaign in rural Cambodia by building a latrine (Pedi, Sophanna, Sophea, & Jenkins, 2013), and had a higher willingness to pay for a flush toilet in Vietnam (Van Minh et al., 2013).

Another important contextual factor is education or literacy (for a study in Ghana see Rodgers et al., 2007; for a study in east-African informal settlements see Okurut & Charles, 2014; for a study in in rural Tanzania see Sara & Graham, 2014). Education was also related to higher uptake of ecological sanitation in rural Uganda (Tumwebaze et al., 2011). In Dar es Salaam, education, although not associated with access to sanitation, was associated with safe pit emptying (Jenkins et al., 2014). Another study in Kenya found that literacy was linked to better quality of pit latrine owned by the respondents (Jackson, 2004).

The influence of the social network is yet another factor influencing access to sanitation. Households were more likely to own latrines if many in their social network or from their surrounding households did so as well (Jenkins & Cairncross, 2010; Shakya, Christakis, & Fowler, 2015). Indeed, in rural India the social network was the most important predictor of latrine ownership even when the influence of caste, education and income was controlled (Shakya et al., 2015), and in Bangladesh subsidies for latrine construction led to increased latrine ownership even for the unsubsidized neighbors (Guiteras, Levinsohn, & Mobarak, 2015).

A completely different yet very important contextual factor is the soil type. Households are less likely to construct latrines if the soil type is unfavorable for doing so (e.g. Jenkins & Curtis,

2005; O'Reilly & Louis, 2014; Okurut & Charles, 2014). In urban areas, also space limits can be a constraint to building latrines (Jenkins & Scott, 2007; Okurut & Charles, 2014).

Other contextual factors that were found to be favorable for having or wanting sanitation facilities were being male and younger (Van Minh et al., 2013), having fewer children (Santos, Roberts, Barreto, & Cairncross, 2011), being Muslim or Christian versus being Pagan (Sara & Graham, 2014), high population density, proximity to a road and presence of piped water (Jenkins & Cairncross, 2010).

Lately, first evidence is emerging, indicating that not only access to sanitation but also latrine cleanliness could be influenced by contextual factors. For example, during the rainy season and during seasons of high human activity, such as market days or holidays, latrines were dirtier in informal settlements of Kampala (Kwiringira et al., 2016). The number of households using a sanitation facility also correlates negatively with its cleanliness (Günther et al., 2012). Correspondingly, facilities shared by several households are not regarded as improved or adequate because it is assumed that they lack cleanliness (Unicef and World Health Organization, 2015). In east african households, latrine cleanliness was correlated with the education and the profession of the household head, with several features of the latrine itself (e.g. the presence of a door, lid, concrete wall and floor), and the disposal of waste water in the latrine (Tumwine et al., 2003). The relation between the quality of latrine construction and its cleanliness has also been found in other studies: latrines were cleaner if they had a lid on the drop hole and a high superstructure in rural Niger (Diallo et al., 2007), latrines were less likely to smell bad and have flies inside them if the superstructure material was of good quality in Uganda (Nakagiri et al., 2015) and Tanzania (Irish, Aiemjoy, Torondel, Abdelahi, & Ensink, 2013), and improved latrines were generally more likely to be clean than unimproved latrines in informal settlements in Kampala (Kwiringira, Atekyereza, Niwagaba, & Günther, 2014). In a cluster-randomized intervention study in Kenyan schools, school latrine cleanliness was increased by simply providing the schools with cleaning material and without any further behavior change intervention (Caruso, Freeman, et al., 2014).

Interestingly, very few studies investigated the influence of the three predominant contextual factors influencing access to sanitation, namely area of living (rural or urban), income and education on latrine cleanliness. Only the study in east Africa found latrine cleanliness to be correlated with education (Tumwine et al., 2003). Moreover, all of the studies presented here are correlational studies, and thus the causalities remain unclear. Although it seems much more plausible that contextual factors influence latrine cleanliness and not vice versa, there could

always be a third factor causing latrine cleanliness and the contextual factors alike. Thus, longitudinal research would be needed to clarify causalities.

This dissertation explores the influence of a range of contextual factors on latrine cleanliness not only with a correlation study but also longitudinally. Study 1 describes the context regarding sanitation and examines contextual factors associated with latrine cleanliness and Study 2 analyzes how changes in contextual factors, namely in quality of latrine construction, affect latrine cleanliness in rural Burundi.

3.2 Psychosocial factors and access to sanitation

To understand why people have access to sanitation or not, it is important to look not only at contextual factors but also at motives and drivers, thus at psychosocial factors. Knowing, for example, why people want to have latrines, is important when it comes to planning a promotion. Moreover, changing psychosocial factors might be easier than changing contextual factors, and they may turn out to be more important than the contextual ones. In a study in Salvador, Brazil, attitudes (e.g., gaining prestige and comfort) better explained the choice of a household to pay to have a toilet connected to a sewer system than socio-economic and demographic characteristics and costs (Santos et al., 2011).

A literature search revealed eight articles looking at the motives why household install or want to install sanitation facilities. Jenkins and Curtis (2005) conducted qualitative in-depth interviews with households in rural Benin. Jenkins and Scott (2007) conducted a household survey in Ghana. Okurut and Charles (2014) conducted a household survey, focus group discussions and key informant interviews in urban informal settlements in Rwanda, Uganda and Kenya. In all three studies, no intervention to promote latrine construction had taken place and if households owned latrines they were self-constructed. Jackson (2004) conducted household surveys, focus group discussions, interviews with key informants to analyze drivers for latrine construction in Kenya. Again, most latrines were self-constructed without subsidies, but programs to promote latrine construction had taken place in some of the study areas. Routray et al. (2015) conducted focus group discussions and qualitative interviews after a program to increase latrine coverage including subsidies in India where many latrines were found to be either unfinished or unused. Dreibelbis et al. (2015) did a follow-up of the study by Routray et al. (2015) and used their results to identify key statements of attitudes towards sanitation, measure them quantitatively and develop an attitudinal scale. Both Dreibelbis et al.'s (2015) and Routray et al.'s (2015) studies were conducted in connection to a large cluster-

randomized trial about the health effects of a sanitation intervention by Clasen et al. (2012). Van Minh et al. (2013) conducted a quantitative survey with households that did not own flush toilets in rural Vietnam to find correlates of willingness to pay for flush toilets. Sara and Graham (2014) report on motives of about 60 households in rural Tanzania who have plans for building a latrine.

In general, the drivers to build sanitation facilities were very similar to the perceived benefits of having sanitation facilities (see section 1.1.2 'benefits of sanitation beyond health'). It is not surprising that people are driven by the benefits they expect to receive when accessing sanitation. The drivers mentioned most often were prestige, privacy, and comfort or convenience. Dignity, prestige or status were found to be an important driver for wanting to or having built a sanitation facility in five of the eight studies (Jackson, 2004; Jenkins & Curtis, 2005; Jenkins & Scott, 2007; Routray et al., 2015; Sara & Graham, 2014). Privacy was important in five studies (Jackson, 2004; Jenkins & Curtis, 2005; Jenkins & Scott, 2007; Okurut & Charles, 2014) and convenience and comfort were important in three studies (Jackson, 2004; Jenkins & Curtis, 2005; Routray et al., 2015). Another driver for wanting to have access to sanitation present in several studies was dissatisfaction with the current defecation place (Jenkins & Curtis, 2005; Jenkins & Scott, 2007; Van Minh et al., 2013). Interestingly, none of the key drivers identified in the studies mentioned here, made it into the final scale prepared by Dreibelbis et al. (2015); the scale measured drivers and attitudes towards sanitation. Instead, Dreibelbis et al. (2015) found that less positive opinion of open defecation, greater perceived social norms regarding latrine use, and fewer reservations about feces and fecal management were correlated with the likelihood of households owning a functioning latrine. There was a little controversy regarding the importance of health gains. They only played a minor role in the studies in Ghana (Jenkins & Scott, 2007) and Benin (Jenkins & Curtis, 2005) but knowing about the health effects of having a latrine was an important correlate of willingness to pay in Vietnam (Van Minh et al., 2013) and also an important motivator for having or wanting latrines in informal settlements in Rwanda, Uganda and Kenya (Okurut & Charles, 2014) and having a plan to build a latrine in Tanzania (Sara & Graham, 2014).

There are only few studies that focused on the drivers of latrine cleaning behavior. All of them were conducted in informal settlements of Kampala but by partly different research groups. The study by Kwiringira et al. (2016), who conducted qualitative research, found that especially during the rainy season women perceived the cleaning of latrines to be very difficult and disgusting. The women said they could not differentiate whether the dirt on the floor was mud

or feces and whether liquids were rainwater or urine. They also mentioned that the generally dirty slum environment did not motivate them to clean the latrines. Tumwebaze and Mosler (2014) conducted semi-structured interviews about cleaning of shared latrines. Respondents reported that latrines were clean if they were cleaned daily and if the cooperation with the other households using them was good. On the other hand, they reported that latrines were unclean if there was a large number of users. Important correlates of cleaning behavior were not disliking to clean, having a daily routin of cleaning, commitment strength and remembering to clean. Good relationships with other users and frequent communication were determinants of cleaning commitment strength (Tumwebaze & Mosler, 2014). In a cross-sectional household survey conducted to find factors associated with cleaning of shared latrines, Tumwebaze, Niwagaba, Günther, and Mosler (2014) found that latrines were cleaned more often if respondents perceived the effort to clean them as small, if they felt disgusted using a dirty toilet, if they talked often to other users, if they believed in their ability to keep the latrine clean and if they had a cleaning habit. Based on that knowledge they were able to conduct a successful promotion to increase cleaning of shared latrines (Tumwebaze & Mosler, 2015).

So far, only very few studies have systematically and quantitatively analyzed psychosocial factors determining latrine cleaning (Tumwebaze & Mosler, 2014, 2015; Tumwebaze et al., 2014). However, they were conducted in an urban environment and focused on cleaning of shared latrines. This dissertation means to investigate psychosocial factors associated with cleaning of privately owned latrines in the context of rural Burundi. Study 1 investigates the psychosocial factors associated with habitual latrine cleaning. Study 2 analyzes effects of a behavior change intervention and how changes in psychosocial factors over time affect habitual latrine cleaning.

4. Behavior change theories

For latrines to be hygienic and clean, they need to be cleaned regularly. The previous sections presented research on the determinants of clean latrines. This section focusses on how to change cleaning behavior and presents behavior change theories as systematic frameworks for analyzing and conceptualizing possible determinants. A new model is introduced to explain habitual latrine cleaning and latrine cleanliness.

4.1 Social-cognitive theories of behavior change

Several social-cognitive theories have been developed to describe how health behavior develops and changes.

One of the earliest models is the health belief model (Rosenstock, 1974). The model is an expectancy-value theory; according to it, health-related behavior is a result of perceived vulnerability, the benefits and costs of the behavior, and the belief that the behavior is beneficial for health. Rogers (1975) protection motivation theory also weights expectancies and values. It postulates two pathways. The first, threat appraisal, is constituted by the perceived severity of and vulnerability to a threat. The second, coping appraisal, is constituted by self-efficacy, confidence in one's ability to perform the behavior, and response efficacy, the belief that the behavior will lead to the desired result.

The theory of reasoned action by Ajzen and Fishbein (1980) is a theory used to describe all kinds of behaviors. It postulates that the attitude toward the behavior and the subjective norm, which is constituted by the opinion of relevant others and the motivation to comply with it, form the intention which leads to behavior. Later, these authors expanded the theory into the theory of planned behavior (Ajzen, 1991; Fishbein & Ajzen, 2011), which additionally incorporates perceived behavioral control, a construct very similar to self-efficacy.

In the transtheoretical model of behavior change (Prochaska, 2013; Prochaska & DiClemente, 1983), behavior change is seen as a process that evolves over time; six different stages of change are proposed: precontemplation, contemplation, preparation, action, maintenance, and termination. People move from not considering a behavior, to considering it by weighting arguments, to preparing for it with planning, to doing the behavior and moving into a stage where it is securely maintained. These authors also postulate that people can always relapse to earlier stages.

In their focus theory of normative conduct, Cialdini, Reno, and Kallgren (1990) build on the concept of norms but argue that norms should be separated into two types: the descriptive norms, what most others do, and the injunctive norms, what most others approve of.

In the social cognitive theory, Bandura (1991; 2004) emphasizes the importance of self-regulative mechanisms such as self-efficacy and personal goal-setting. He posits these personal factors to be in a dynamic interplay with the environment – roles, models, and relationships – and with the behavior. Gollwitzer (1993; 1999) introduces the concept of implementation intentions. He sees self-regulation as the main problem if intentions do not lead to the execution of behavior. He postulates that more detailed plans of when, where and how the behavior should be executed, which he terms implementation intentions, are more likely to be put into action. Building on this idea and expanding it, Schwarzer (2008) developed one of the most recent theories, the health action process approach. This is a stage model that also takes phases into account. In a motivational phase, perceived self-efficacy, outcome expectancies, and risk perception influence whether a behavioral intention is formed. The volitional phase is the key to the actual performance of the behavior. It includes action planning, basically the same as implementation intentions, coping planning, making plans how to cope with barriers, and the maintenance and recovery of self-efficacy.

The risks, attitudes, norms, abilities, and self-regulation (RANAS) model of behavior change by Mosler (2012) is an attempt to integrate all these theories into one. It groups the psychosocial factors of behavior from the models into five blocks. Table 2 displays the five factor blocks and the theories they are based on. Risk factors represent a person's understanding and awareness of the health risk. Attitudinal factors relate to a person's positive or negative stance towards a behavior and the outcomes of the behavior. Norm factors represent convictions about the incidence of a behavior and how the social network views the behavior as well as personal standards. Ability factors represent a person's confidence in her or his ability to practice a behavior and to manage possible barriers. Finally, self-regulation factors represent a person's capacity to plan and self-monitor a behavior and to manage conflicting goals and distracting cues. Even though the RANAS model is not a stage model, the post-intentional factors are considered in this block. The psychosocial factors are thought to influence behavior, habit, and use. The RANAS model not only considers healthy behaviors but also unhealthy ones which might obstruct the healthy behaviors. For example, when considering the healthy behavior of using a household filter for drinking water, the unhealthy behavior of drinking unfiltered water should also be considered.

Table 2. Overview of the RANAS model and the theories it includes

Factor Group	Behavioral factors	Theories derived from
Risk factors	Perceived vulnerability	Health belief model (Rosenstock, 1974)
	Perceived severity	Protection motivation theory (Rogers, 1975)
	Factual knowledge	Health action process approach (Schwarzer, 2008)
Attitude factors	Instrumental beliefs	Theory of planned behavior (Ajzen, 1991; Fishbein & Ajzen, 2011)
	Affective beliefs	
Norm factors	Descriptive norm	Theory of planned behavior (Ajzen, 1991; Fishbein & Ajzen, 2011)
	Injunctive norm	
	Personal norm	Focus theory of normative Conduct (Cialdini et al., 1990)
Ability factors	Action knowledge	Theory of planned behavior (Ajzen, 1991; Fishbein & Ajzen, 2011)
	Self-efficacy	
	Maintenance self-efficacy	Health action process approach (Schwarzer, 2008)
		Social cognitive theory (Bandura, 1991, 2004)
Self-regulation factors	Action control	Health action process approach (Schwarzer, 2008)
	Action planning	Implementation intentions (Gollwitzer, 1993, 1999)
	Coping planning	Transtheoretical model of behavior change (Prochaska & DiClemente, 1983)
	Remembering	
	Commitment	

The RANAS model is also a framework for developing and testing behavior change interventions. Basically, the idea is that a first quantitative survey measures behavioral factors and behavior. From this, it is determined which psychosocial factors are most important for the behavior. The model then proposes behavior change techniques to tackle these factors with an intervention. Ideally, the success of the intervention to change the behavior and the psychosocial factors is evaluated with a second survey or even a third for measuring long-term effects.

Up to now, the RANAS approach has been used to analyze predictors of health behavior (e.g. (Lilje, Kessely, & Mosler, 2015; Stocker & Mosler, 2015) and has been implemented successfully, in Bangladesh for the promotion of safe water (Inauen & Mosler, 2014) and in Ethiopia for the promotion of safe water (Huber, Tobias, & Mosler, 2014) and handwashing (Contzen, Meili, & Mosler, 2015). In Uganda, it was used for planning and implementing an intervention to increase the cleaning of shared latrines (Tumwebaze & Mosler, 2015). The authors implemented group discussions and commitment techniques which changed behavior

through psychosocial factors such as commitment strength, cleaning ease, and injunctive norms.

4.2 Frameworks and theories for health behavior change in developing countries

The last section presented social-cognitive theories of behavior change and the RANAS model. Aboud and Singla (2012) have pointed out that developmental health programs most often plan their activities by using logical frameworks which simply assume that an activity leads to a desired outcome. They state that this is often not the case and that theory is needed to fill the gap. Recently, several theories or frameworks have been developed to explain behavior change and develop health behavior intervention in developing countries. Some of them, such as the Evo-Eco model (Aunger & Curtis, 2014) or the integrated behavioral model (Dreibelbis, Winch, et al., 2013) can be used for WaSH behaviors in general; others such as the community-led total sanitation approach (Chambers & Kar, 2008) or SaniFOAM (Devine 2009) have been developed specifically for sanitation-related behaviors. What most of these models have in common is that they put more emphasis on the context or the environment than the classical social-cognitive behavior change theories do. The following paragraphs provide an overview of these models.

The Evo-Eco model (Aunger & Curtis, 2014) is a very elaborate model that can be used for all kinds of health behaviors in developing countries. Based on the idea of evolutionary biology, it emphasizes the great ability of individuals to adapt and assumes that it is mainly the environment that makes individuals change rather than the individuals as actors. It presumes that the brain, the body, and the environment interact dynamically. All of these should be taken into account when planning interventions. Although the model acknowledges cognitive and rational aspects, it rather emphasizes the motivational system within the brain, with key motivators such as disgust, comfort, and nurture, and the habitual system, an automatic system reactive to cues which leads to routine. The environment is divided into physical, biological, and social elements. The approach has been applied in a large-scale handwashing intervention in India (Biran et al., 2014).

The integrated behavioral model for water sanitation and hygiene (Dreibelbis, Winch, et al., 2013) was developed for interventions that go beyond the focus of the individual and household levels. It is a multi-level model based on a matrix of five aggregate levels that operate through three dimensions. These are the contextual dimension, the psychosocial dimension, and the technological dimension. The aggregate levels go from the societal/structural level down to the

habitual level within the individual. This matrix, with 15 fields, can be used as a checklist for planning interventions. The approach has been used to design a handwashing station (Hulland et al., 2013), to explain filter use (Najnin et al., 2015), and to evaluate a hygiene intervention in Nepal (McMichael & Robinson, 2016).

Comparison of the Evo-Eco model (Aunger & Curtis, 2014) and the integrated behavioral model for water sanitation and hygiene (Dreibelbis, Winch, et al., 2013) shows how difficult it is to categorize the environment/context and factors predicting WaSH behavior. The two models provide quite different solutions. For example, shame and nurture are localized within the brain in the Evo-Eco model as a motivational determinant, but in the integrated behavioral model they are found at the household level. Further, factors which all belong in the social environment within the Evo-Eco model are found within all three dimensions of the integrated behavioral model (e.g. policies and regulations in the contextual dimension, leadership within the psychosocial dimension, ownership and access within the technological dimension). These are just some of the differences. Still, the two models both put strong focus on the context/environment and on habits.

Other models worth mentioning include the WaSH behavior change: ABCD (Egreteau, 2015), an approach which was specifically developed for a non-governmental organization, and the predictive model of communication for water treatment and safe storage behavior (Figueroa & Kincaid 2010), in which environmental factors such as the burden of disease, access to water, sanitation, and household technologies play important roles.

Several models have been developed specifically for behavior change related to sanitation. They focus on latrine construction and latrine use or on both. Jenkins and Curtis (2005) developed a model that explains the motivation of wanting a latrine based on their qualitative study (already mentioned in previously, p. 7). It states that the motivation to build a latrine is influenced by awareness of the availability of a latrine and comes from dissatisfaction caused by a discrepancy between the current sanitary sanitation and the desired sanitary situation. Further, physical and social conditions, originating in the village environment and individual lifestyle, also play a role. Again, this model emphasizes the importance of the context.

In a later study, Jenkins and Scott (2007), developed a stage model for latrine adoption. In the first, the preference stage, people would prefer to have a latrine. This is influenced by dissatisfaction with current defecation practice and awareness of latrines. Indeed, this is very similar to their previous model (Jenkins & Curtis, 2005). The second stage is the intentional

stage, in which people start planning how to acquire a latrine. This state is influenced by the priority of change amongst competing goals and the absence of permanent constraints to acquiring a latrine. These constraints could be lack of technical knowledge, material or personal resources. The last stage is the choice stage, in which people are very likely to build a latrine very soon. It is influenced by the absence of temporary constraints to acquiring a latrine. In this model again, contextual factors such as possible constraints and physical and social conditions are very important.

Devine (2009) developed the SaniFOAM framework for the planning of sanitation interventions. SaniFOAM stands for sanitation focus, opportunity, ability, and motivation. Focus means defining the target behavior and population. Opportunity, ability, and motivation are used to find behavioral determinants. Questions here include whether individuals have the opportunities, like access to or availability of products. Questions concerning ability address knowledge, skills, social support, decision making power, and whether they can afford a product. Motivation is examined by looking at attitudes and beliefs, values, drivers, competing priorities, intention, and willingness to pay. This model does not put as much emphasis on context as others, but the context is still included in the opportunity part of the model. The SaniFOAM framework has been applied to explain latrine adoption in Tanzania (Sara & Graham, 2014) and is used by the Water and Sanitation Program, which is part of the World Bank Group's Water Global Practice, to plan sanitation programs.

One framework which is not a theory but a widely used behavior change approach is the community-led total sanitation approach. It was introduced in Bangladesh in 2000 by Kamal Kar to empower rural villages in particular to change their sanitation situation themselves. It aims to stop open defecation by all households (Chambers & Kar, 2008). Instead of providing subsidies for latrine construction, the approach uses another set of activities, such as showing pathways of fecal contamination and mapping open defecation areas to induce shame and disgust, and it encourages social pressure so that the village can be declared open defecation free. It also encourages civic pride by celebrations of the open-defecation-free status. Nowadays, the approach is used in more than 50 countries. Although several handbooks exist, there is no single approach to the community-led total sanitation approach, and it is implemented with differing elements in different countries (Sigler, Mahmoudi, & Graham, 2014). For example, in India, it is implemented as part of the government’s total sanitation campaign and even includes subsidies (Pattanayak et al., 2009). Although case studies and qualitative studies have evaluated its success (e.g. Harvey, 2011; Lawrence et al., 2016; Sah &

Negussie, 2009), quantitative studies are still few and contradictory (for positive results see Pattanayak et al., 2009; for mixed results see Barnard et al., 2013; Whaley & Webster, 2011; for no effects found see Guiteras et al., 2015).

Very recently, Neal and Vujcic (2016) have proposed a framework for nudging and habit change to end open defecation. Nudging refers to nudges, which are small changes in the environment that foster decision making and behavior change. The framework is based on Kahnemann's dual process theory, which proposes two systems of information elaboration (Kahneman, 2011). System 1 works with relatively automatic and cue-driven drivers, and System 2 with conscious and motivational drivers. Neal and Vujcic acknowledge that behavior is always the product of both systems but criticize most theories for focussing solely on the conscious System 2. Their framework therefore focusses on System 1, especially for the formation of habits rather than context. The authors acknowledge that context can influence habit formation, for example through cues. No studies have yet evaluated any application of the approach, but the authors give examples for the application of its principles (e.g. the consistent availability of soap for the formation of regular handwashing Luby et al., 2009).

Two more models are worth mentioning briefly. Santos et al.'s (2011) hybrid choice model presumes that the household's choice of sanitary option is mainly influenced by its socio-economic characteristics and attitudes and that attributes of the options as well as culture influence the choice. A model called the toilet tripod by O'Reilly and Louis (2014) emphasizes the three legs of their tripod for the diffusion of latrines: political will, social pressure (from neighbors and through knowledge of toilets), and political ecology (changing land use, assured access to water, and compatible soil type).

To reiterate, the theories developed for health behavior change in developing countries place strong emphasis on the context. However, they differ in their understanding of what belongs in the context and how to categorize it. Seimetz (2015), after reviewing the integrated behavioral model (Dreibelbis, Winch, et al., 2013), the Evo-Eco model (Aunger & Curtis, 2014), the theory of triadic influence (Flay, Snyder, & Petraitis, 2009), and the social ecology model of health promotion (Stokols, 1992), proposes a simple and straightforward categorization of contextual factors. She divides the environment into the social, physical, and personal contexts. The social context includes culture and social relations, laws and policies, the prevailing economic conditions, and the information environment. This is very similar to the social context proposed in the Evo-Eco model. The physical context is also similar to that in the Evo-Eco model and

includes the built environment, technical features of objects, and the natural environment. The personal context refers to socio-demographic factors such as age, sex, and education. However, there are also some uncertainties. It is not sure whether roles and responsibilities in the household as well as household structure (e.g. number of people) should be subsumed into the personal context, as attributes of the person, or rather into the social context as part of social relationships. Furthermore, not all contextual factors fit strictly into just one of the three contexts. Some belong to several contexts. For example, living in a city influences the physical context, as a city is a built environment with completely different infrastructure to rural areas, and the social context, as social relationships, living, and culture tend to differ in a city from those in the countryside. It may even influence the personal context, as income and education can be different in the city.

Seimetz (2015) originally developed this categorization of context for handwashing behavior, but lately (Mosler & Contzen, 2016) have used it to extend the RANAS model and thus for all kinds of WaSH-related behaviors. Figure 1 shows the extended RANAS model. It basically remains the same as the original model; now, however, the social, physical and personal contexts influence how behavior change techniques are implemented, psychosocial factors, and how these psychosocial factors translate into behavior. Behavior A refers to the healthy behavior and behavior B to the unhealthy one which should be considered equally.

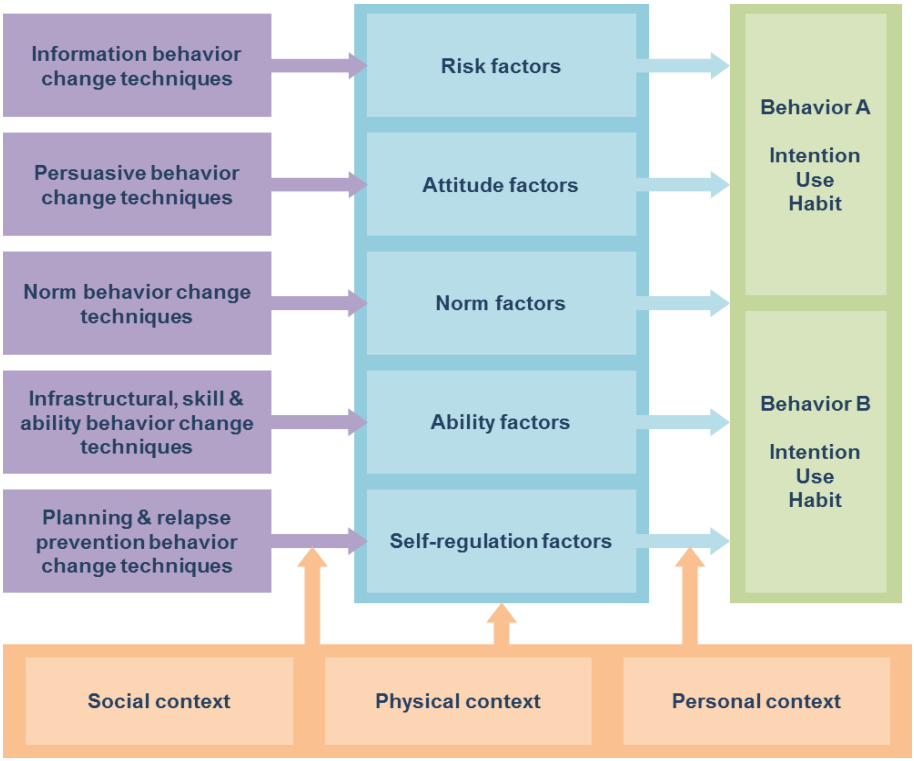

Figure 1. The extended RANAS Model of Mosler and Contzen (2016)

4.3 Framework explaining habitual latrine cleaning and latrine cleanliness

The previous subsection presented frameworks for health behavior change in developing countries. However, although frameworks for sanitation behavior exist, their focus is on latrine construction and use rather than on latrine cleaning. In the following, a new framework for the specific case of latrine cleanliness is introduced (Figure 2). Basically, it is an adaptation of the extended RANAS model for the case of latrine cleaning. However, unlike the RANAS model, it does not stop at behavior but goes further by also looking at latrine cleanliness separately as the outcome of behavior.

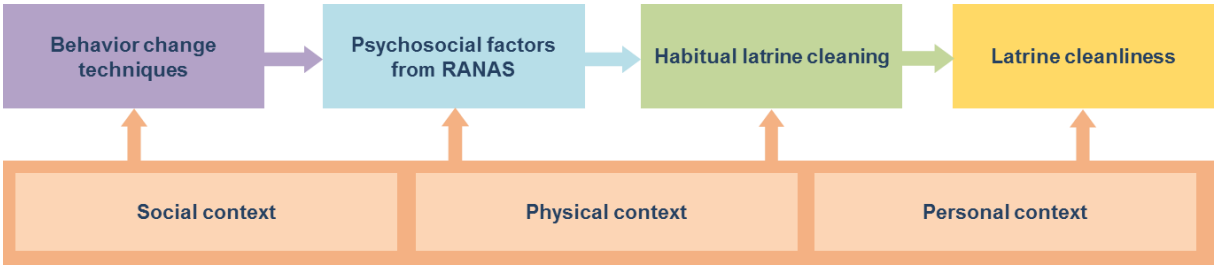

Figure 2. Framework explaining habitual latrine cleaning and latrine cleanliness

Going from left to the right, the violet box and the blue box are exactly the same as in the RANAS model, but shown without details. The psychosocial factors are the determinants of behavior and can be influenced through behavior change techniques. The green box displays the behavior, habitual latrine cleaning. It is habitual latrine cleaning and not merely latrine cleaning, because habits are crucial for the maintenance of behavior (e.g. Tobias, 2009). Their importance has been emphasized by several of the theories presented (framework for nudging and habit change Neal & Vujcic, 2016; integrated behavioral model Dreibelbis, Winch, et al., 2013; Evo-Eco Aunger & Curtis, 2014) and also represent an important outcome in the RANAS model. The concept of habitual latrine cleaning is based on the idea of habitual behavior developed by Inauen, Tobias, and Molser (2013) for the use of arsenic-free water in Bangladesh. It combines the actual behavior with the habit.

Up to this point, the framework is congruent with the extended RANAS model. However, unlike the RANAS model, the desired outcome, in this case latrine cleanliness, is shown additionally and separately in the yellow box. This is related to the influence of the contextual factors. I argue that it is crucial that some behaviors and their desired outcomes are examined separately. This is because the contextual factors can influence the desired outcome directly and not only through the behavior. This seems to be the case for latrine cleanliness. The studies presented in the section on contextual factors influencing latrine cleanliness suggest that the

contextual factors influence latrine cleanliness directly and not just through habitual latrine cleaning. Kwiringira et al. (2016), for instance, pointed out that latrines were dirtier on market days. Presumably this is not due to less cleaning but because many, possibly careless, people use the latrine. Similarly, Günther et al. (2012) reports that the more households shared latrines, the dirtier they were. This is also not caused simply by the habitual cleaning of one household but by the behavior of the other households as well. This distinction between behavior and desired outcome is reasonable for many behaviors. For example, in the case of handwashing and hand cleanliness, hands could be contaminated even though washed at all key moments (before touching food and after possible contact with feces) if the household environment is dirty and hands are contaminated, for example, by touching door handles.

The contextual factors are displayed in orange at the bottom of the framework. They are the same as those proposed by Seimetz (2015) and influence behavior change techniques, the psychosocial factors of the RANAS model, habitual latrine cleaning, and latrine cleanliness. Household-related factors (e.g. roles, responsibilities, and household size) are categorized as personal in this dissertation, because interventions often aim at households as units and not just the individuals in them.

This dissertation aims to test the utility of this framework in explaining habitual latrine cleaning and latrine cleanliness. It aims to show how psychosocial factors influence habitual latrine cleaning, how behavior change techniques can change habitual latrine cleaning, whether they do so over their effect on determinants, and how habitual latrine cleaning influences latrine cleanliness. In regard to the context, this dissertation mainly looks at the influence of contextual factors on latrine cleanliness.

Study 1 describes factors of the social, physical and personal context that affect sanitation. It examines how the contextual factors and habitual latrine cleaning relate to latrine cleanliness. Further, it analyzes the psychosocial factors associated with habitual latrine cleaning.

Study 2 looks at the effects of an intervention on psychosocial factors, habitual latrine cleaning, and latrine cleanliness and at the effects of the intervention on quality of latrine construction. It determines whether changes in habitual latrine cleaning were caused by psychosocial factors. Further, it analyzes the effects of changes in habitual latrine cleaning and changes in contextual factors, specifically the quality of latrine construction, on latrine cleanliness.

5. General hygiene

So far, this introduction has focused on access to sanitation, especially latrine cleanliness, and behavior change models to improve habitual latrine cleaning. This section takes a closer look at habitual latrine cleaning as one of many hygiene behaviors and thus at hygiene behaviors from a more general perspective. In this dissertation, I argue that hygiene behaviors are related to each other and propose the concept of general hygiene, wherein I propose that one consistent attitude influences all daily routines and practices related to hygiene. At the end of this section, general hygiene and latrine cleanliness are presented within a framework.

5.1 Relationships between hygiene behaviors

According to the World Health Organization, hygiene is defined as conditions and practices that help to maintain health and prevent the spread of diseases (World Health Organization, n.d.). In recent years, several questionnaires have been developed and used to measure hygiene behavior. They ask questions about different fields of hygiene, from tooth brushing to cleaning the house and have found the items to be strongly correlated. Most importantly, factor analysis reveal that one concept, which the authors usually call general hygiene, can explain all items. This is consistent with the concept of general hygiene that I propose in this dissertation. Further, research has shown that different hygiene behaviors are correlated, not only when measured by self-report but also when measured by observations.

The first self-reported general hygiene questionnaire was the hygiene inventory (HI23) developed in Australia by Stevenson et al. (2009). It divides general hygiene into four domains: hand hygiene, personal grooming, household cleanliness, and food-related hygiene. These domains were defined after conducting a factor analysis over 50 questions. The final inventory contains 23 Likert-scale items; it provides a scale for general hygiene and subscales for each domain. The authors provide evidence for external validity by correlating the general scale with gender, profession, depression, and having small children. Further, they report good reliability for both the subscales and the general scales. The fundamental finding of Stevenson et al.'s (2009) research for this dissertation is that the subscales and the general scales are all correlated. The authors conclude that hygiene behavior in one domain is likely to predict hygiene behavior in another. This finding is consistent with the concept of general hygiene that I propose; all items in the HI23 questionnaire were related to each other and are thus likely to all be influenced by one consistent attitude. Furthermore, the subscale for household cleanliness contains a

question about the frequency of toilet cleaning. Toilet cleaning is thus conceptualized by the authors as a part of the household cleanliness domain, which is in turn part of overall hygiene behavior. To date, the HI23 has been replicated twice in Turkey (Altun, Cinar, & Dede, 2010; Erkal, 2011) and once in Brazil (da Costa, Loffredo, Ambrosano, & Pinelli, 2016). In all three studies, the results were good regarding reliability, and the conceptual structure of the four hygiene domains were confirmed.

Saffari et al. (2014) developed a questionnaire to measure hygiene amongst Iranian military personnel. Items measured hygiene behaviors over fields such as oral hygiene, nail care, handwashing, and wearing clean clothes. The authors report good reliability measures and they found a unidimensional structure through principal component analysis. Again, one could use the concept of general hygiene to explain these findings.

The most recent self-reported hygiene questionnaire was developed in Turkey to measure hygiene among nursing students (Ipek Coban & Bilgin, 2015). Similar to the HI23, it assumes several domains of hygiene and an overall general hygiene. Ipek Coban and Bilgin (2015) define three domains of hygiene as personal hygiene, hand-washing hygiene and food-related hygiene. Like the other hygiene questionnaires presented, all the items were correlated, and the internal consistency was high. Once more, the concept of general hygiene could be used to explain these findings.

The evidence on the three hygiene questionnaires presented thus far supports the concept of general hygiene being responsible for all kinds of different hygiene behaviors. However, there could be an alternative explanation for the strong correlations between the items in the questionnaires: social desirability. Self-reports on hygiene behaviors are believed to be potentially distorted by social desirability (e.g. Contzen, De Pasquale, & Mosler, 2015; Halder et al., 2010; Ram, 2013), and it is possible that the correlations between the different self-reported hygiene behaviors are caused simply by social desirability. What is more difficult to explain only by social desirability are the findings of different domains of hygiene (Ipek Coban & Bilgin, 2015; Stevenson et al., 2009). However, social desirability might be unequally strong for the different domains, for example if people believe that it is more socially acceptable to live in a dirty apartment than not to take care of personal hygiene. Even if one believes it is unlikely that social desirability is the sole cause of the correlations between self-reported hygiene behaviors, it is still possible that social desirability makes the correlations between them stronger. On another point, the questionnaires still need to be tested with poor populations in developing countries, as so far they have only been tested in developed and emerging nations.

The following paragraphs present research about hygiene behaviors in developing countries and measured by other means than self-reports, for example by structured observation or by spot-checks. As with the questionnaires on hygiene, several studies have found associations between different hygiene behaviors. The associations indicate that they could be influenced by general hygiene.

Self-reports on hygiene behaviors may be distorted not only by social desirability but also by wrong memory recall (e.g. Contzen, De Pasquale, & Mosler, 2015; Halder et al., 2010; Ram, 2013). To overcome these problems, behavior can be measured by structured observations or by spot-checks. Structured observations are often considered the most reliable method, especially for handwashing behavior (Ram, 2013). However, they are time-consuming and expensive, as an observer must accompany the person to be observed for several hours; this can also be socially awkward for both of them. It is also unclear how reactive they are (Ruel & Arimond, 2002). Spot-checks are observations too, but they do observe the outcomes of behaviors, which serve as proxy for the behaviors (e.g. clean water container as proxy for the cleaning of the water container). Spot-checks can also use observations of prerequisites of behavior as proxies, such as the presence of soap as proxy for handwashing with soap. They have the advantage that they are fast and easy to conduct and less reactive than self-reports (Ruel & Arimond, 2002).

Several hygiene behaviors seem to be associated with each other. Studies have reported that households that are rated hygienic or that wash hands are more likely to own a latrine (for a study in Brazil see Strina, Cairncross, Barreto, Larrea, & Prado, 2003; for a study in Benin see Johnson et al., 2015; for a study in Bangladesh see Hoque, Mahalanabis, Alam, & Islam, 1995). Thus, general hygiene seems to predict the likelihood of having a latrine.

In a study of hygiene behaviors measured with spot-checks, Kaltenthaler and Drašar (1996) reported the impression that certain hygiene behaviors clustered. Unfortunately, the authors remain very unspecific about this observation and present no analysis of it. Bartlett, Hurtado, Schroeder, and Mendez (1992) are more specific in a study they conducted in rural Guatemala. They found that all kinds of spot-checks were strongly correlated, from baby bottle on the ground to the hands of the mother being dirty. Webb et al. (2006) also conducted a study using spot-checks in rural Guatemala. They used 15 spot-checks and created a summary index and four separate indices for drinking water, food, personal hygiene, and domestic household hygiene. Even though they do not report on correlations between spot-checks, they report that

any six spot-checks suffice to predict the value of the total summary index within a range of 20%. Thus the spot-checks could predict each other and were also related to each other.

These studies lend additional support to the idea that general hygiene influences all kinds of hygiene behaviors, especially because it is much less likely that the correlations between spot-checks are caused by social desirability. As with the studies using questionnaires to measure general hygiene, the idea of the existence of different domains of hygiene arose in one of the spot-check studies (Webb et al., 2006). However, unlike the questionnaire studies, these domains were simply assumed and not statistically tested for.

5.2 General hygiene framework

So far, the idea of general hygiene has been introduced along with research that shows how a range of different hygiene behaviors may all be influenced by general hygiene. Here, the link of general hygiene to the previous sections will be clarified by introducing a framework which relates general hygiene, including habitual latrine cleaning and latrine cleanliness, to behavior change (Figure 3).

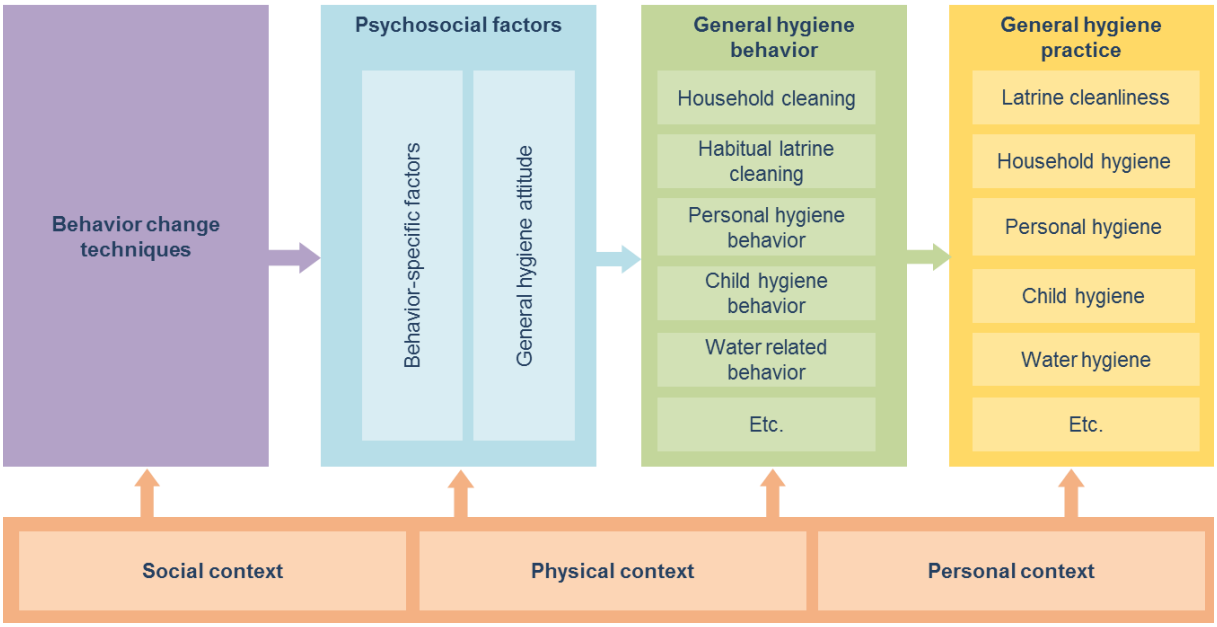

Figure 3. General hygiene framework

Before explaining the framework as a whole, it is necessary to examine the general hygiene practice block (in yellow) in greater detail. This block is called general hygiene *practice* because it refers to the outcomes of behavior that can be measured by spot-checks. As these are not actually behaviors, it seems more appropriate to speak of a practice. As suggested by several authors, general hygiene practice is divided into different domains. Boot and Cairncross (1993)

suggested clustering hygiene into five behavioral domains. They proposed disposal of human feces, use and protection of water sources, water and personal hygiene, food hygiene, and domestic and environmental hygiene. Webb et al. (2006) created an index to measure general hygiene with spot-checks and proposed different hygiene domains. Research on questionnaires measuring hygiene has confirmed the existence of different domains by factor analysis (Ipek Coban & Bilgin, 2015; Stevenson et al., 2009). The general hygiene practice block I propose follows the conceptual structure of the HI23 hygiene questionnaire (Stevenson et al., 2009) quite closely but difference in that it is not concerned with behavior directly but with behavioral outcomes. Like the items from HI23, all behavioral outcomes are assumed to be correlated and to form general hygiene practice together. In addition, five domains of hygiene are proposed in which the spot-checks are more closely related. The domains proposed are latrine cleanliness, personal hygiene, child hygiene, household hygiene, and water hygiene; together, these constitute general hygiene practice, whilst acknowledging that there may be more domains. Latrine cleanliness is one domain of general hygiene practice. What is not shown in the framework is that each domain can contain several behavioral outcomes. For example, personal hygiene could include hand cleanliness, the cleanliness of clothing, and face cleanliness.

It is proposed that general hygiene behavior (in green) influences general hygiene practice. It contains a series of behaviors which are grouped into different domains corresponding to those of general hygiene practice. Habitual latrine cleaning is one of these, and it influences latrine cleanliness.

The blue block represents psychosocial factors. These factors influence general hygiene behavior. It contains two kinds of factors, the behavior-specific psychosocial factors from the RANAS model and general hygiene attitude. General hygiene attitude is proposed to be the psychological mindset that influences general hygiene behavior. If different hygiene behaviors are related and occur simultaneously, I presume that an attitude towards general hygiene steers them all. Nonetheless, it is unlikely that general hygiene attitude alone is responsible for general hygiene behavior. Behavior-specific psychosocial factors are still important. Their relevance for behavior has been amply demonstrated by numerous studies (e.g. Huber & Mosler, 2013; Inauen & Mosler, 2014; Lilje et al., 2015). Postintentional factors in particular call for a behavior-specific treatment; for example, the coping mechanisms for the availability of soap are probably quite different from those for ensuring that water is always kept in closed containers. It is beyond this framework to show how general hygiene attitude and the psychosocial factors from the RANAS model interact and which is more important. Any

attempt to do this would be largely speculation, as the research field of general hygiene is quite new and no research on psychosocial factors associated to general hygiene has yet been published.

The violet block stands for the behavior change techniques. They are the same as in the RANAS model. The contextual factors are shown at the bottom. Social context, physical context, and personal context can all influence behavior change techniques, psychosocial factors, general hygiene behavior, and general hygiene practice.

In the previous section, I presented a specific framework for latrine cleanliness. This second framework for general hygiene is an addition and extension of the first framework. Latrine cleanliness is one domain of general hygiene practice and thus associated with many other behavioral outcomes. Nonetheless, it is influenced by habitual latrine cleaning, which is assumed to be one domain of general hygiene behavior. What is new regarding the psychosocial factors is that not only the RANAS factors influence general hygiene behavior, and thereby habitual latrine cleaning, but also the general hygiene attitude. As in the specific framework for latrine cleanliness, behavior change techniques can be used to change psychosocial factors.

This general hygiene framework shows a conceptualization of general hygiene that includes behavior change theory. This dissertation focusses mainly on the last block, general hygiene practice. There is already evidence that hygiene measured by self-report can be divided into several domains of hygiene that together form general hygiene behavior (Ipek Coban & Bilgin, 2015; Stevenson et al., 2009). If evidence of general hygiene behavior or general hygiene practice could be found using spot-checks instead of self-reports, this would give strong evidence to the concept as the possible influence of social desirability would be minimized. The main aim of this dissertation is thus to test the conceptual structure of general hygiene practice. Further, it aims to explore the links of general hygiene practice to behavior, both self-reported and measured by structured observations, and to psychosocial factors. Study 3 is dedicated to these themes. The concept of general hygiene is important to latrine cleanliness because it may be that hygiene behaviors such as habitual latrine cleaning should be examined not in isolation but within the broader framework of general hygiene.

6. Research questions

The aim of this dissertation is to contribute to a better understanding of how to ensure the cleanliness of latrines to improve people's health and general well-being. First, this dissertation explores how contextual factors and habitual latrine cleaning contribute to cleanliness. Second, psychosocial factors influencing habitual latrine cleaning are analyzed with the intention of developing and testing an intervention. Third, latrine cleanliness is not only looked at in isolation but within the framework of hygiene generally, as different hygiene behaviors are presumed to depend on each other and on general hygiene attitude.

A specific framework for latrine cleanliness was presented that conceptualizes latrine cleanliness as the outcome of habitual latrine cleaning (Figure 2). Various psychosocial factors derived from the RANAS model (Mosler, 2012) influence habitual latrine cleaning and can be changed by behavior change techniques, also derived from the RANAS model. Contextual factors, namely social, physical, and personal contexts, influence this process and latrine cleanliness itself. Study 1 and Study 2 address research questions based on this framework.

Study 1 is a correlational study. It was conducted in three provinces of rural Burundi. It reports the situation of a rural population regarding sanitation and explores the extent to which latrine cleanliness is influenced by contextual factors as well as habitual latrine cleaning. Further, it analyzes psychosocial factors influencing habitual latrine cleaning. It poses three specific research questions:

1.1 What are the environmental conditions and practices concerning sanitation and latrines?

1.2 What are the determinants of latrine cleanliness? To what extent is it about habitual latrine cleaning and to what extent does it concern contextual factors?

1.3 What are the psychosocial factors associated with habitual latrine cleaning?

Study 2 is a longitudinal study following up on Study 1. It tests the effects of an intervention that aimed to improve latrine cleanliness and the quality of latrine construction. It analyzes how the intervention changed psychosocial factors and if changes in them caused habitual latrine cleaning to improve. Further, it analyzes causes of changes in habitual latrine cleaning and latrine cleanliness irrespective of the intervention. It addresses six specific research questions:

2.1 Does the intervention lead to improved habitual latrine cleaning as well as to improved observed latrine cleanliness?

2.2 Does the intervention lead to improved quality of latrine construction?

2.3 Does improved habitual latrine cleaning and improved quality of latrine construction lead to improved observed latrine cleanliness?

2.4 How does the intervention affect psychosocial factors?

2.5 How well do changes in psychosocial factors explain changes in habitual latrine cleaning?

2.6 Do the psychosocial factors mediate the effect of the intervention on habitual latrine cleaning?

The results of Study 1 and Study 2 will contribute to the evidence base on the factors influencing latrine cleanliness and thus may improve the planning and effectiveness of interventions.

A second framework was conceived in the introduction as an extension of the specific framework for latrine cleanliness but incorporating habitual latrine cleaning and latrine cleanliness as parts of general hygiene behavior and practice (Figure 3). In short, the framework assumes that all hygiene behaviors are related to each other and together form general hygiene behavior. Different domains are proposed, with similar behaviors being more closely related to each other. Latrine cleanliness is one domain of general hygiene practice, which is formed by a various behavioral outcomes. Habitual latrine cleaning is a part of general hygiene behavior, which in turn results in general hygiene practice. Psychosocial factors and general hygiene attitude influence general hygiene behavior and can be changed through behavior change techniques.

Study 3 is based on this general hygiene framework. It is a correlational study using the same sample as Study 1. It uses structural equations to model general hygiene practice on the basis of spot-checks as behavioral outcomes. Even though general hygiene behavior and general hygiene attitude are not modelled, it analyzes the relationships of hygiene behaviors and psychosocial factors with general hygiene practice. It also looks at the relationship of general hygiene practice to health. It addresses four specific research questions:

3.1 Does the construct general hygiene practice explain all kinds of hygiene behaviors, and do different domains of hygiene practices exist?

3.2 Is general hygiene practice as measured with spot-checks related to hygiene behaviors that are measured with self-report or structured observations?

3.3 Does general hygiene practice relate to commitment to hygiene behaviors?

3.4 Is general hygiene practice related to health outcomes?

The results will help to better conceptualize the interdependence of a variety of hygiene behaviors, including habitual latrine cleaning. This will widen the focus from isolated hygiene behaviors to general hygiene as a whole.

Chapter II

Why are some latrines cleaner than others? Determining the factors of habitual cleaning behavior and latrine cleanliness in rural Burundi

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Abstract

Access to improved sanitation is fundamental for the prevention of diarrhea and other diseases. However, for a sanitation facility to be safe, its cleanliness must be assured. The aim of the present study was, first, to assess how cleaning behavior, household characteristics and infrastructural factors influenced latrine cleanliness and, second, to assess which psychological factors influenced cleaning behavior. In a study in rural Burundi, 762 standardized household interviews with the primary household caregiver were carried out to assess habitual cleaning behavior and psychological factors according to behavior change models. In addition, the characteristics and cleanliness of the latrine were observed, and two multiple linear regressions were performed to analyze predictors of latrine cleanliness and of cleaning behavior. Latrine cleanliness was determined by cleaning behavior, the possibility of locking the door, the height of the superstructure, the material of the superstructure and the availability of an even slab. The number of households or people sharing the latrine was not influential. Commitment to cleaning, satisfaction with the cleanliness of the latrine and self-efficacy determined habitual cleaning behavior. Interventions focusing on commitment, self-efficacy and satisfaction with a clean latrine like public commitment or guided practice interventions are recommended to promote cleaning behavior.

Keywords: Sanitation, Cleaning, Diarrhea, Behavior Change, Sub-Saharan Africa, Burundi

Introduction

Diarrhea is preventable, but remains one of the main causes of death in under-five-year olds in developing countries (Chopra et al., 2013; WHO/UNICEF, 2013). Along with improved hygiene practices and access to safe water, sanitation is fundamental for the prevention of diarrhea. Access to sanitation is estimated to reduce diarrhea incidence by more than 30% (Brown, Cairncross, & Ensink, 2013; Curtis et al., 2011; Montgomery & Elimelech, 2007).

The benefits of sanitation are not only limited to health. In Benin and Ghana it was found that prestige, well-being and situational goals were more important than the expected health gains (Jenkins & Curtis, 2005; Jenkins & Scott, 2007). Similarly, Diallo et al. (2007) found that the main perceived benefit of newly installed pit latrines in Niger was not health gains but easy access and privacy. Research has also indicated the subjective importance of latrine cleanliness to users. Tumwebaze, Orach, Niwagaba, Luthi, and Mosler (2013) found that most latrine users in Kampala slums were dissatisfied with their sanitation facilities due to low cleanliness and over-demand. In a project in Ghana, cleanliness was mentioned as the main advantage of latrines besides health benefits and convenience (Rodgers et al., 2007).

Of even greater significance than the subjective importance of latrine cleanliness are the health hazards associated with the use of dirty toilets (Sijbesma, 2008). Importantly, the World Health Organization (WHO) has acknowledged the importance of latrine cleanliness by designating latrines as improved only if they are properly maintained as well as clean (WHO/UNICEF 2013).

Despite its relevance, the number of studies concerning correlates or predictors of latrine cleanliness is still limited. Recently, Günther et al. (2012) found a negative correlation between the cleanliness of a latrine and the number of households or people sharing it. Tumwine et al. (2003) found latrine cleanliness to be correlated with the profession of the household head, the presence of a door, lid and concrete wall and floor, and the disposal of waste water in the latrine. Tumwebaze et al. (2014) found importance of using a clean toilet, efforts involved in cleaning the toilet, disgust felt from using a dirty toilet and cleaning habits as the main determinants of the intention to clean shared toilets.

This study aims to identify factors that influence latrine cleanliness. Several “structural factors” have conceivable influences: the first is the number of households and people per latrine.

Furthermore, the type of slab or the existence of a cover plate, for example, could influence latrine cleanliness in terms of ease or difficulty of cleaning. Users might also be influenced by the quality of the superstructure of the latrine, taking more or less care when using it. The presence of a door could influence how safe or hurried people feel when using the latrine. A lock on the door could limit access, especially to careless strangers, further resulting in higher levels of cleanliness. Differences between cleaning methods could also result in different levels of cleanliness.

The most obvious, though not necessarily effective, predictor of latrine cleanliness is not structural but simply how often the latrine is cleaned. Verplanken & Wood (2006) further emphasized the importance of habits, especially in health-related contexts because impact is most acute with daily, habitual cleaning. A new concept of "habitual behavior", which includes both behavior and habit, has already been proposed and tested in Bangladesh (Inauen et al., 2013).

Assuming that habitual cleaning behavior is an important predictor of latrine cleanliness, it is crucial to understand which socio-cognitive factors predict this practice. The Risk, Attitudes, Norms, Abilities and Self-regulation (RANAS) model of behavior was especially developed to predict health behavior in developing countries (Mosler, 2012). It consists of a comprehensive description of psychological factors derived from well-established health models. The model groups the various factors into five blocks: risks, attitude factors, norm factors, ability factors and self-regulation factors. Risk factors pertain to all factors that address an individual's understanding and awareness of the health risk. Attitudinal factors express a positive or negative stance towards the behavior. Norm factors represent convictions in relation to the incidence of behavior and how a social network thinks about behavior. Abilities represent aptitudes that an individual believes he or she must have to acquire behavior. Finally, self-regulation addresses the continuation and maintenance of behavior.

The present study

A cross-sectional study was conducted in three rural provinces in Burundi. This study is part of a larger study on hygiene and sanitation practices in rural Burundi. The focus of this paper lies on latrine cleanliness and the psychological determinants of habitual cleaning behavior. The paper aims to answer the following research questions:

- 1.1 What are the environmental conditions and practices concerning sanitation and latrines?
- 1.2 What are the determinants of latrine cleanliness? To what extent is it about habitual cleaning behavior and to what extent does it concern structural factors?
- 1.3 What are the psychological determinants of habitual cleaning behavior?

Material and methods

Research area

Burundi is rated as one of the 10 countries with the lowest human development index worldwide. The mortality rate amongst under-fives is 142 per 1000 births (UNDP, 2013). The Republic is divided into 17 provinces, which are further divided into 117 communes. On the lowest administrative level are the collines, which is French for "hills", and refers to the nature of Burundi's landscape.

Sample frame

The study was conducted in three of the 17 provinces of Burundi, namely, Bururi, Kirundo and Ruyigi. All three provinces are rural and people rely on self-sustaining farming. In each of the three provinces, two communes were randomly selected. In addition, the collines closest to and farthest from the commune's chief village were chosen, resulting in 12 collines. The villages were not part of any specific program on hygiene or sanitation. Caretakers of children under the age of five were interviewed.

Survey deployment

The random route method was applied for selecting approximately 60 households per colline. A total of 762 households were surveyed, 250 in Bururi, 255 in Kirundo and 257 in Ruyigi. Structured face-to-face interviews and spot-check observations on hygiene were conducted. Spot-checks are short observations where the interviewer fills out a checklist about the conditions he or she encounters. A team of ten local students or social workers balanced by gender and ethnic group was recruited as interviewers. They were trained over 8 days on the questionnaire, with a focus on bias issues and on social skills. Ethical approvals were given by the Burundian authorities and the affiliated university of the authors.

Questionnaire

The questionnaire was simultaneously developed in English and French. It was professionally translated from French to Kirundi, the local language, and re-translated into French for verification. Spot-check observations of various features of the latrine, like its cleanliness, the

availability of a slab and the quality of the superstructure were conducted (Table 3). Objective criteria were given to the interviewers. A latrine was defined as clean if the floor was well swept and no feces were observable.

Table 3. Variables used for regression analysis on latrine cleanliness

Variable Name	Scale	Lowest Value	Highest Value	Collection
Latrine cleanliness	3 pts.	1 = dirty	1 = clean	Spot-checks
Household size				Question
Private/shared	2 pts.	0 = shared	1 = private	Question
Cover plate	2 pts.	0 = no cover plate	1 = cover plate	Spot-checks
Slab availability	2 pts.	0 = no slab	1 = wooden or cement slab	Spot-checks
Height of superstructure	2 pts.	0 = waist high	1 = man high	Spot-checks
Material of superstructure	2 pts.	0 = straw, banana leaves or wood	1 = clay	Spot-checks
Possibility to lock	3 pts.	0 = no door (.5 = door without lock)	1 = door with lock	Spot-checks
Cleaned with water	2 pts.	0 = no mention of water	1 = mention of water	Question
Cleaned with broom	2 pts.	0 = no mention of broom	1 = mention of broom	Question
Cleaned with ashes	2 pts.	0 = no mention of ashes	1 = mentions ashes	Question

The psychological variables were measured quantitatively as proposed by the RANAS model. Unipolar questions were measured with 5-point Likert scales and bipolar questions with 9-point Likert scales (Table 4).

Table 4. Variables used for regression analyses on habitual cleaning behavior

Factor block	Variable name	Wording	Scale	Lowest value	Highest value
Behavioral Factors	Habitual cleaning behavior (3 questions)	How often do you clean the latrine?	5 pts.	0 = never	1 = daily
		How often does it happen that you forget to clean the latrine?	5 pts.	0 = almost each time	1 = almost never
		To what extent do you feel that you clean the latrine as a matter of habit?	5 pts.	0 = not a habit	1 = a very strong habit
Risk Factors	Perceived vulnerability of child	How high do you feel is the risk that your child gets diarrhea?	5 pts.	0 = no risk	1 = high risk
	Risk perception	How likely is it that you get diarrhea if you don't use a clean latrine for defecation?	5 pts.	0 = no risk	1 = high risk
	Perceived severity of child	Imagine your child contracted diarrhea; how severe would that be?	5 pts.	0 = not severe at all	1 = very severe
Attitudinal Factors	Instrumental beliefs: effort	Do you think that cleaning the latrine is effortful?	5 pts.	0 = not effortful	1 = very effortful
	Instrumental beliefs: health	How certain are you that cleaning the latrine prevents you from getting diarrhea?	5 pts.	0 = not certain	1 = very certain
	Likes cleaning	How much do you like or dislike cleaning the latrine?	9 pts.	-1 = dislike it very much	1 = like it very much
	Likes to use clean latrine	How much do you like or dislike using a clean latrine?	9 pts.	-1 = dislike it very much	1 = like it very much
	Disgust when using dirty latrine	Do you think it is disgusting to use a dirty latrine?	5 pts.	0 = not disgusting	1 = very disgusting
	Satisfaction with cleanliness	How satisfied are you with the average cleanliness of the latrine?	5 pts.	0 = not satisfied	1 = very satisfied
Norm Factors	Descriptive norm	How clean are the other latrines in your community?	5 pts.	0 = very dirty	1 = very clean
	Injunctive norm	People who are important to you, do they rather think you should or you should keep the latrine clean?	9 pts.	-1 = nearly all disapprove	1 = nearly all approve
	Personal norm	Do you feel a personal obligation to clean the latrine?	5 pts.	0 = no personal obligation	1 = strong personal obligation
Ability Factors	Self-efficacy	Do you think you are always able to keep the latrine clean?	5 pts.	0 = not able	1 = very able
	Perceived behavioral control	How difficult is it to always keep the latrine clean?	5 pts.	0 = not difficult	1 = very difficult
	Maintenance self-efficacy	How confident are you that you can clean the latrine even if you have a lot of other things to do or even if you don't feel like cleaning it?	5 pts.	0 = not confident	1 = very confident
	Recovery self-efficacy	Imagine you have stopped cleaning the latrine for a long time. How confident would you be to start over?	5 pts.	0 = not confident	1 = very confident
S-R Factors	Coping planning	How do you ensure that the latrine is always kept clean?	2 pts.	0 = no plan	1 = has plan
	Commitment	Do you feel committed to cleaning the latrine?	5 pts.	0 = not committed	1 = very committed

Note: Original scales ranging from 0 to 4, resp. –4 to 4 were transformed to scales ranging from 0 to 1, resp. –1 to 1.

Since the question about monthly income could not be answered by more than half of the households, proxy measures were used to assess household wealth. The interviewers noted the quality of the roofing material of the dwelling and asked whether anyone in the household owned a mobile phone. Interviewees were further asked about their education and if they had ever received sensitization about open defecation. These questions acted as control variables (Table 5).

Table 5. Control variables

Variable name	Scale	Lowest value	Highest value	Collection
Education mother	2 pts.	0 = primary school not completed	1 = primary school completed	Question
Mobile phone ownership	2 pts.	0 = no one in household owns mobile phone	1 = at least one person in household owns mobile phone	Question
Dwelling's roofing material	2 pts.	0 = roof of dwelling is made of low quality material (e.g. straw or banana leafs)	1 = roof of dwelling is made out of corrugated iron or tiles	Spot-checks
Sensitization open defecation	2 pts.	0 = Does not recall ever having received sensitization on open defecation	1 = recalls having received sensitization on open defecation	Question

Data analysis

We calculated Cronbach's alpha to assess the reliability of "habitual cleaning behavior". With $\alpha = 0.77$, it was considered reliable to combine the single items into one variable. To answer the two research questions, we calculated two simultaneous multiple regressions to identify significant determinants of habitual cleaning behavior and latrine cleanliness. Assumptions of linearity, homoscedasticity, independent and normally distributed errors and multicollinearity were met for both regressions.

Results

Descriptive statistics

Female respondents made up 99.6% of the sample, and in the majority of cases, they were married (76.2%) or cohabiting (13.9%). The mean number of people living in a household was 5.89 (SD = 2.12), ranging from two to 16. Only 18% of the sample completed primary school. Participants were mostly Catholic (57.4%) or Protestant (40.1%), and the remainder were either Muslim or Atheist. The main livelihood of the vast majority was farming and/or livestock production (95.0%). The two proxy measures for household wealth revealed that in 31.9% of the household's someone owned a mobile phone. The roofs of the dwellings were mostly (80.3%) made out of corrugated iron or tiles. Further, 62.3% of the interviewees recalled having been sensitized on open defecation.

General results regarding the sanitary situation

Access to latrines was high (95.7%), and 80.9% of the household having access to sanitation had private latrines. Most of the shared latrines (80.5%) were shared by only two households. Participants reported a very high frequency of latrine use; 86.0% "always" used it, while 13.0% used it "often". The reported use for participants' children was much lower: 45.9% reported that their children "always" used the latrine, while 35.1% reported that their children used it "often". Interviewers tried to verify latrine use by checking the surroundings of the houses for feces. In most cases (76.6%), no feces were found. Interviewers reported that mostly children's feces were found, thereby reaffirming the reported lower use by children. More feces were found close to households not having access to sanitation (54.5%) than close to households having access to sanitation (21.9%). Further feces were detected less often 15.9% in households reporting that their children "always" used the latrine (15.9%) than in of the household reporting lower use (27.8%).

All latrines were pit latrines; most were rudimentarily covered with wooden sticks and soil (75.1%); some had cement slabs (12.0%), others had wooden slabs (8.4%), and some were simply open pits (2.7%). Cover plates on latrines were very rare, and only 7.5% of latrines had one; 4.2% of latrines had no superstructure, and if there was one, it was more often waist-high (56.8%) than human-height (38.9%); 30.7% of latrines had superstructures made out of clay,

29.0% made of straw, 26.6% made of banana leaves, and 7.3% made of wood; most latrines (88.0%) had no door, some had a door without a lock (4.7%), while others had a door with lock (7.2%).

In most cases, interviewers rated latrine cleanliness as mediocre (47.3%), dirty (26.4%) or clean (26.3%). When asked who normally cleaned the latrine, respondents stated that most often, they did it themselves (80.3%). Otherwise, "all the women in the family" (7.5%), "no one" (3.4%), "all the sharing households" (3.0%), "everyone" (2.6%) and "others" (3.2%) were given as responses. Respondents stated that most often, they cleaned the latrine everyday (41.9%), otherwise, they cleaned it twice weekly (22.3%), once weekly (13.3%), fortnightly (7.6%) or practically never (10.5%). Respondents were asked how they cleaned their latrine (multiple answers were possible). They mostly reported that they cleaned with a broom or hoe (91.7%), but that they also cleaned with ashes (36.1%) and water (29.4%).

Habitual cleaning behavior and psychological factors

Table 6 presents descriptive statistics of all variables used for the regression analyses. Generally, respondents reported a high level of habitual cleaning behavior (Mean [M] = 0.69). Psychological factors recorded positive means towards cleaning. The very low perceived vulnerability of getting diarrhea (M = 0.30) stood in contrast with the very high perceived severity of getting diarrhea (M = 0.91). The majority of respondents reported that they had become sensitized to getting diarrhea (63%) and to the effects of open defecation (63%). Arrangements with other users about cleaning (36%) existed, and arguments about cleaning (M = 35%) occurred, but were not the norm. The mean of the frequency of communication (M = 0.60) reflected that respondents talked approximately weekly about hygiene related matters.

Table 6. Means and frequencies of variables used for regression analyses

Factor Block	Item/Factor	*n*	Min	Max	M	SD
Variables for First Regression						
	Latrine cleanliness	697	-1	1	0.00	0.73
Structural Factors	Household size	762	2	16	5.89	2.12
	Private/shared	738	0	1	0.81	0.39
	Cover plate	697	0	1	0.07	0.26
	Slab availability	728	0	1	0.20	0.40
	Height of superstructure	699	0	1	0.41	0.49
	Material of superstructure	751	0	1	0.30	0.46
	Possibility to lock	718	0	1	0.10	0.27
	Cleaned with water	762	0	1	0.29	0.46
	Cleaned with broom	762	0	1	0.91	0.29
	Cleaned with ashes	762	0	1	0.36	0.48
Variables for Second Regression						
	Habitual cleaning behavior	730	0	1	0.69	0.23
Risk Factors	Perceived vulnerability of child	762	0	1	0.71	0.34
	Risk perception	761	0	1	0.76	0.22
	Perceived severity of child	762	0	1	0.95	0.10
Attitude Factors	Instrumental beliefs: effort	728	0	1	0.15	0.27
	Instrumental beliefs: health	729	0	1	0.32	0.25
	Likes to clean	730	–1	1	0.63	0.25
	Likes using clean latrine	729	–1	1	0.73	0.20
	Disgust when using dirty latrine	729	0	1	0.83	0.21
	Satisfaction with cleanliness	729	0	1	0.64	0.21
Norm Factors	Descriptive norm	726	0	1	0.54	0.19
	Injunctive norm	722	–1	1	0.68	0.23
	Personal norm	729	0	1	0.73	0.22
Ability Factors	Self-efficacy	728	0	1	0.60	0.25
	Perceived behavioral control	729	0	1	0.18	0.27
	Maintenance self-efficacy	727	0	1	0.72	0.15
	Recovery self-efficacy	729	0	1	0.77	0.13
S-R Fact.	Coping planning	724	0	1	0.60	0.49
	Commitment	728	0	1	0.69	0.21
Control Variables						
	Sensitization open defecation	757	0	1	0.63	0.48
	Education mother	759	0	1	0.18	0.39
	Mobile phone ownership	762	0	1	0.32	0.47
	Dwelling's roofing material	762	0	1	0.80	0.40

Note: theoretical MIN and MAX values of variables are provided.

Predictors of latrine cleanliness

To answer the research question on the predictors of latrine cleanliness, we conducted a linear

regression analysis (Table 7). All variables in the model are spot-checks observations except habitual cleaning behavior which is self-reported. The model displays a mediocre explanation of variance (adj. $R^2 = 0.323$). Five predictors were found to be significant: "habitual cleaning behavior" ($\beta = 0.304$), "possibility to lock" ($\beta = 0.190$), "height of superstructure" ($\beta = 0.182$), slab ($\beta = 0.093$) and "material of superstructure" ($\beta = 0.091$). Habitual cleaning behavior was the strongest predictor; the higher peoples' habitual cleaning behavior, the cleaner were their latrines. Additionally, the better the possibility of closing or locking latrines, the cleaner they were. If they had a human-height superstructure, they were cleaner compared to waist-high superstructures. Further, if the superstructure was made of clay or mud, rather than straw or banana leaves, the latrines were cleaner. Lastly, if latrines had a slab, they were more likely to be clean.

Education of the interviewee had no influence. Whereas "dwelling's roofing material" was a significant predictor for latrine cleanliness "mobile phone ownership", the other proxy for household wealth was not significant. No differences of cleanliness of the latrines were found during different periods of the day.

Table 7. Linear regression analyses for latrine cleanliness and habitual cleaning behavior

Variable	B	SE B	β
Regression on latrine cleanliness[a]			
(Constant)	–1.030	0.150	
Habitual cleaning behavior	0.995	0.121	0.299***
Household size	–0.006	0.012	–0.018
Private/shared	0.058	0.065	0.031
Cover plate	0.121	0.096	0.044
Slab availability	0.174	0.066	0.098**
Height of superstructure	0.251	0.055	0.171***
Material of superstructure	0.134	0.058	0.088*
Possibility to lock	0.496	0.099	0.190***
Cleaned with water	–0.005	0.057	–0.003
Cleaned with broom	–0.127	0.118	–0.037
Cleaned with ashes	0.049	0.052	0.033
Education mother	–0.057	0.064	–0.031
Mobile phone ownership	–0.015	0.054	–0.010
Dwelling's roofing material	0.243	0.068	0.125***
Regression on habitual cleaning behavior[b]			
(Constant)	0.013	0.067	
Perceived vulnerability of child	0.027	0.017	0.039
Risk perception	–0.030	0.025	–0.028
Perceived severity of child	–0.062	0.052	–0.027
Instrumental beliefs: effort	–0.040	0.021	–0.046^{+}
Instrumental beliefs: health	–0.024	0.021	–0.026
Likes to clean	0.054	0.027	0.058*
Likes to use clean latrine	0.049	0.031	0.041
Disgust when using dirty latrine	–0.016	0.026	–0.014
Satisfaction with cleanliness	0.200	0.029	0.181***
Descriptive norm	0.094	0.029	0.075**
Injunctive norm	0.014	0.025	0.014
Personal norm	0.065	0.025	0.061*
Self-efficacy	0.132	0.026	0.144***
Perceived behavioral control	–0.036	0.025	–0.040
Maintenance self-efficacy	–0.062	0.044	–0.040
Recovery self-efficacy	–0.004	0.050	–0.002
Coping planning	0.001	0.012	0.002
Commitment	0.560	0.036	0.492***
Sensitization open defecation	0.034	0.011	0.069**
Education mother	0.006	0.013	0.010
Mobile phone ownership	0.013	0.011	0.026
Dwelling's roofing material	0.025	0.013	0.042^{+}

Note: [a] adjusted $R^2 = 0.323$, [b] adjusted $R^2 = 0.677$, $^{+}p < 0.1$, *p < 0.05, **p < 0.01, ****p < 0.001, a forced entry method was used for the calculation.

Predictors of habitual cleaning behavior

To answer the research question on the predictors of habitual cleaning behavior, linear regression analyses (Table 7) were performed. The model displays a high explanation of variance (adj. $R^2 = 0.677$). Six psychological factors significantly influenced habitual cleaning behavior ($p < 0.05$). The three factors with the strongest influence were "commitment" ($\beta = 0.471$), "satisfaction with cleanliness" ($\beta = 0.173$) and "self-efficacy" ($\beta = 0.148$). People who felt committed to cleaning their latrines, those who were more satisfied with its cleanliness, and those who felt confident about their ability to clean ("self-efficacy") recorded higher levels of habitual cleaning behavior. There were three additional factors whose influence was notably smaller: "perceived vulnerability of child" ($\beta = 0.051$), "likes to clean" ($\beta = 0.059$) and "personal norm" ($\beta = 0.059$). It has to be noted that commitment correlated strongly with "likes to clean" ($r = 0.53$), self-efficacy ($r = 0.52$) and maintenance self-efficacy ($r = 0.50$). Therefore, these factors might have had a stronger influence on their own, even though they may not have recorded significant results in the final regression analyses.

Of the control variables entered to the regression, the two variables "sensitization open defecation" ($\beta = 0.069$) and "dwellings roofing material" ($\beta = 0.042$) had some weak influence. People who recalled having received sensitization on open defecation had a somewhat stronger habitual cleaning behavior as did people with a higher household wealth indicated by having a roof of better quality on the dwelling. However, the ownership of a mobile phone by someone in the household, the second proxy for household wealth, had no influence and neither did the education of the interviewee.

Discussion

The aim of the present study was to analyze sanitary conditions in three provinces in rural Burundi. Of primary interest were questions relating to latrine cleanliness. We determined predictors of latrine cleanliness as well as of habitual cleaning behavior.

General sanitary situation

The results showed that while latrine access was almost universal, there were serious deficits in terms of their cleanliness and how they were built. Open defecation was only a marginal problem for adults, but children routinely practiced it. It is understandable why small children often did not use latrines. Falling into the pit posed serious risks; most latrines were not equipped with a cover plate and were rudimentarily covered with wood. Open defecation by children is not negligible, as there is evidence that it poses a health risk (Buttenheim, 2008; Tumwine et al., 2002). Further, only one-tenth of the latrines had cement slabs and could be considered improved by WHO (WHO/UNICEF 2012) standards.

Latrine cleanliness

Latrine cleanliness was generally mediocre; only one-quarter of the latrines sampled were rated as clean, while the remainder was rated as average or dirty. The strongest determinant of latrine cleanliness was the habitual cleaning behavior of the caretaker. This result is very important because it meant that caretakers had a certain control over the cleanliness of their latrines, and therefore, interventions aimed at improving habitual cleaning behavior could potentially be successful in increasing latrine cleanliness. Further, latrines with a door, or a door with a lock, were cleaner than latrines without these features. This result is consistent with Tumwine et al. (2003) who also found that latrines with doors were more likely to be clean. This could be due to the resulting limited latrine access, especially of careless strangers. Latrines were also cleaner when the superstructure was human-height rather than only waist-high; if they had an even slab made of cement or wood and if the walls were made of clay rather than straw or banana leaves. Latrines with even slabs might be cleaner because people take more care when using them or because they are easier to clean. This is also one reason why they are promoted, for example, by UNICEF (Brandberg, 1996; Yepdujo, Guerre, & Niamey, 1999).

Considering the fact that only unshared sanitation has been categorized as improved due to a

fear of unhygienic conditions (WHO/UNICEF 2012), it is somewhat surprising that neither a shared latrine nor the number of people using it has an influence on its cleanliness. However, it must be noted that shared latrines are mostly shared by two households only. This is clearly under the threshold proposed by Günther et al. (2012), who recommend a maximum of four households per latrine to still be acceptable or improved.

The different cleaning techniques (using a broom, water or ashes) had no effect on cleanliness. It appeared that each technique could be efficient if it was carried out properly. It should be noted that with the rather low R square, not much of the variance in latrine cleanliness could be explained. This indicates that some important predictors were missing from the model. The care of users is one factor, which we suspect might be essential but which was not measured. Another reason for the low explained variance was our measurement. Even though no correlation between time of the day and cleanliness was found it is probable that latrine cleanliness fluctuated over the course of the day. Our measurement represented a momentary state rather than the permanent state of latrine cleanliness. Indeed, Ruel & Arimond (2002) recommend multiple measurements in their review of the spot-check literature.

The results were controlled for education, the ability to recall previous sensitization and household wealth. Education had no influence. People who could recall having been sensitized about open defecation had cleaner latrines. The data indicated that household wealth influences cleanliness to a certain extent. Interestingly, whether or not a household owned a mobile phone did not influence cleanliness whereas whether or not the roofing of the dwelling was of high quality did. Presumably, those two proxies measure different aspects of household wealth. The quality of the roofing is an investment for the wellbeing of the whole family whilst the mobile phone is mostly an investment of one person of the household only. Thus, it could be speculated that latrine cleanliness is not so much related to the households wellbeing but more to the willingness to invest in wellbeing in a way that makes the whole family benefit.

Habitual cleaning behavior

Participants recorded high levels of habitual cleaning behavior. In terms of explained variance, the RANAS model seems to be suitable because nearly 70% of the variance of habitual cleaning behavior could be explained. Altogether, the three most important predictors of habitual cleaning behavior were commitment to cleaning, satisfaction with the cleanliness of the latrine

and self-efficacy. As Cialdini (2007) notes, individuals who are committed to a certain behavior are more likely to perform that behavior because they do not want to be inconsistent. Similarly, in Kampala slums personal norm, which is very similar to commitment, was the most important predictor of cleaning intentions (Tumwebaze et al. 2014). The result of commitment being a predictor of cleaning behavior is also in line with research in Ethiopia and Bangladesh where commitment was found to be an important predictor of choosing a safe water option (Huber & Mosler, 2013; Inauen, Tobias, & Mosler, 2014).

Satisfaction with the cleanliness of the latrine was a strong predictor of habitual cleaning behavior. However, as our study is only cross-sectional, causalities were unclear. It seems most plausible that people who report a higher level of habitual cleaning behavior are more satisfied with the cleanliness of their latrine. Yet, especially in the longer term, the opposite also seems to hold. For instance, satisfaction was found to be a fundamental predictor of whether change in health behavior was maintained (see Baldwin et al. [2006] for smoking cessation or Finch et al. [2005] for weight loss). There could be a positive feedback loop between satisfaction with the cleanliness of the latrine and habitual cleaning behavior. In sanitation research, the importance of satisfaction has been stressed in the context of decision-making towards improving sanitary situations (Tumwebaze et al., 2013; Van Minh et al., 2013).

The last important predictor of habitual cleaning behavior was self-efficacy. As stated by Bandura (2010), self-efficacy is an important determinant of behavior. Similar to our results, self-efficacy was positively correlated with hand-washing behavior in Haiti and the choice of a safe water option in Bangladesh (Contzen & Mosler, 2013; Mosler, Blöchliger, & Inauen, 2010).

The risk factors were irrelevant, only the perceived vulnerability of children had a small influence on habitual cleaning behavior. So the individual understanding or awareness of health risks, in this case diarrhea, had no impact on behavior. This is in line with various studies on health behavior in developing countries (Huber et al. 2012; Contzen & Mosler 2013; Inauen et al. 2014; Tamas et al. 2013).

Socio-economic variables could explain only very few of the differences in habitual cleaning behavior: there was a very weak influence of recalling having been exposed to sensitization and of one of the two proxy measures for household wealth. In addition, the education level had no influence, which stands in contradiction to a study conducted in Ghana where education was

the most important factor for good childcare practices (Armar-Klemesu et al. 2000).

It should be noted that causality statements could not be made in connection with this study because it was only cross-sectional. Longitudinal data are needed to show whether the predictors causally influenced latrine cleanliness and habitual cleaning behavior over time.

Implication for practice and conclusion

Gaining knowledge of specific situations and circumstances in relation to sanitation is essential for practitioners. There was no need to make interventions to prevent open defecation by adults in the three Burundian provinces of the study, whereas open defecation by children was still frequent. The promotion of potties, as proposed by Curtis et al. (2011), would be a solution. Further, latrine standards and their overall cleanliness should be tackled. Habitual cleaning behavior best explained latrine cleanliness. Moreover, certain structural factors, such as the existence of a door and lock, the height of the superstructure, the quality of the material of the superstructure and the existence of a slab, also proved to be important. Higher latrine standards seem to have positively influenced cleanliness. However, as already noted, the data is correlative and not causal. The core predictors of habitual cleaning behavior were commitment, satisfaction with cleanliness and self-efficacy. Interventions should therefore aim at these factors rather than at risk factors, which had no influence. In a public commitment intervention, participants would pledge to clean regularly; additionally, a highly visible sign of commitment, such as a flag for their roof, could be given to them. Emphasizing satisfaction regarding latrine cleanliness can be very useful when creating persuasive messages for multimedia campaigns. To improve self-efficacy, guided practice interventions can be conducted and participants can be encouraged to visit and help each other to instill social help.

Chapter III

Improved Latrine Cleanliness through Behavior Change and Changes in Quality of Latrine Construction: A Longitudinal Intervention Study in Rural Burundi

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A similar version of this paper is under review for publication at Psychology and Health.

Abstract

Access to safe and clean sanitation facilities is fundamental for the prevention of diarrhea.

We evaluated the effects of a theory- and evidence-based intervention on increasing latrine cleanliness and quality of latrine construction in a longitudinal study. We analyzed how the intervention influenced psychosocial factors and how those in turn influenced habitual latrine cleaning. In addition, we assessed whether observed latrine cleanliness was improved by changing habitual latrine cleaning and by improving quality of latrine construction.

Observed latrine cleanliness increased in the intervention group (N = 198) but decreased in the control group (N = 91): the number of latrines classified as clean increased from 21% to 31% in the intervention group, but decreased from 37% to 27% in the control group. Improved habitual latrine cleaning led to cleaner latrines: households whose behavior improved were 3.48 times more likely also to improve in their observed latrine cleanliness (chi-square test: χ^2 = 16.36, $p < .001$). Much of the change in habitual latrine cleaning was explained by changes in psychosocial factors, as shown by a multiple regression model (adj. r^2 = .46). The most important predictors were changes in *forgetting* (β = -.26), *personal norm* (β = .18), *commitment strength to cleaning the latrine* (β = .17) and *satisfaction with latrine cleanliness* (β = .16). However, the intervention did not affect those factors. Instead, it affected *disgust in cleaning the latrine* and the *descriptive norm*. We found that improvements in the quality of latrine construction also led to cleaner latrines; for instance, households that had installed a lid were 7.39 times more likely to have a cleaner latrine (χ^2 = 4.46, $p < .05$) or 3.26 more likely if they had built a superstructure from solid material such as clay (χ^2 = 6.84, $p < .005$).

We conclude that the intervention improved latrine cleanliness. Improved habitual latrine cleaning and better quality of latrine construction led to higher cleanliness. Even though changes in psychosocial factors explained changes in habitual latrine cleaning very well, there was little evidence that they mediated the effect of the intervention.

Keywords: Sub-Saharan Africa; Burundi; Behavior Change; Sanitation; Evidence-Based Intervention

Introduction

The Sustainable Development Goals commit the international community to achieving access to adequate and equitable sanitation and hygiene for all by 2030 (UN General Assembly, 2015). The WHO/UNICEF Joint Monitoring Program (JMP) uses the term adequate sanitation to refer to sanitation services that safely manage reuse and treatment of excreta (JMP, 2015). In sub-Saharan Africa, pit latrines are the most common sanitation facilities (Graham & Polizzotto, 2013). They are regarded as basic or improved sanitation if they hygienically separate excreta from human contact (JMP, 2015). This requires that the latrine slab is clean and free of feces. Not only are unclean sanitation facilities believed to constitute a health hazard (Sijbesma, 2008), but there is also the risk that users return to open defecation if sanitation facilities are dirty; this was the case in informal settlements in Kampala (Kwiringira, Atekyereza, Niwagaba, & Günther, 2014) and Mumbai (McFarlane, 2008). It is thus fundamental not only to promote access to sanitation facilities but also to ensure their cleanliness.

Yet the focus on latrine maintenance and cleanliness is relatively new to research. Several cross-sectional studies have shown the linkage between the quality of latrine construction and cleanliness. Latrines in rural and urban Uganda, Kenya, and Tanzania were less likely to be contaminated with feces if they had a door, a lid on the drop hole, or a concrete wall or floor (Tumwine et al., 2003). The same was found in rural Niger for latrines with a lid on the drop hole and a high superstructure (Diallo et al., 2007). In informal settlements in Kampala, improved latrines in general were more likely to be clean than unimproved latrines (Kwiringira, Atekyereza, Niwagaba, & Günther, 2014). Similarly, superstructure material was related to both smell and presence of flies in studies conducted in Uganda (Nakagiri et al., 2015) and Tanzania (Irish, Aiemjoy, Torondel, Abdelahi, & Ensink, 2013).

However, even a well-built latrine will become dirty if users do not clean it regularly, so behavior change may be needed to ensure regular cleaning. There is increasing evidence that behavior change interventions should be based on scientific theory (Taylor, Conner, & Lawton, 2012; T. Webb, Joseph, Yardley, & Michie, 2010). One such is the RANAS approach (Mosler, 2012), which was specifically developed to explain water, sanitation and hygiene-related behaviors and to design interventions in developing countries. It defines psychosocial factors determining behavior on the basis of quantitative data. It incorporates psychosocial factors leading to behavior change that are described by well-established theories such as the health

belief model (Rosenstock, 1974), the reasoned action approach (Fishbein & Ajzen, 2011), and the health action process approach (Schwarzer, 2008). It groups psychosocial factors into five blocks. Risk factors represent a person's understanding and awareness of the health risk. Attitudinal factors relate to a person's positive or negative stance towards a behavior. Norm factors represent perceived social pressure towards a behavior. Ability factors represent a person's confidence in her or his ability to practice a behavior. Finally, self-regulation factors represent a person's capacity to plan and self-monitor a behavior and to manage conflicting goals and distracting cues. Several studies have shown the success of interventions designed using the RANAS approach, for example in Bangladesh (Inauen & Mosler, 2014) and Ethiopia (Contzen, Meili, et al., 2015; Huber et al., 2014; Sonego, Huber, & Mosler, 2013). An intervention based on the RANAS approach increased cleaning of shared latrines in informal settlements in Kampala by changing psychosocial factors such as cleaning obligation, cleaning ease, and affective beliefs (Tumwebaze & Mosler, 2015).

The present study

The aim of this longitudinal study was to test the effects of a theory- and evidence-based intervention using the RANAS approach on latrine cleanliness in rural Burundi. We wanted to analyze how the intervention would influence psychosocial factors and how those in turn would influence behavior. Moreover, we wanted to assess how changes in the quality of latrine construction would influence cleanliness. The current intervention draws on the results of a baseline study published elsewhere (Sonego & Mosler, 2014). We found that nearly all households owned private pit latrines but that these generally exhibited poor quality of construction. In addition, their cleanliness was often unsatisfactory. Observed latrine cleanliness was related to the quality of construction (e.g. the door having a lock, the height of the superstructure, the material of the superstructure and the slab material), but the strongest link was to habitual latrine cleaning. We therefore developed an intervention, based on the RANAS approach, which targeted specific psychological factors to improve habitual latrine cleaning and the quality of latrine construction. In a follow-up survey, we compared the intervention to a control group to test whether habitual latrine cleaning and observed latrine cleanliness improved between the baseline study and the follow-up study. We addressed six specific research questions. (2.1) Does the intervention lead to improved habitual latrine cleaning as well as to improved observed latrine cleanliness? (2.2) Does the intervention lead to improved quality of latrine construction? (2.3) Does improved habitual latrine cleaning and

improved quality of latrine construction lead to improved observed latrine cleanliness? (2.4) How does the intervention affect psychosocial factors? (2.5) How well do changes in psychosocial factors explain change in habitual latrine cleaning? (2.6) Do the psychosocial factors mediate the effect of the intervention on habitual latrine cleaning?

Methods

Research area

We randomly selected one municipality in each of three rural provinces of Burundi, Ruyigi, Kirundo and Bururi. Two villages were then selected in each municipality.

Sample and data gathering

In each village, households were selected using the random-route method (Hoffmeyer-Zlotnik, 2003). Caretakers of children under the age of five were interviewed using face-to-face structured interviews and short observations. In the baseline survey in October and November 2012, 380 households were interviewed, about one third of the households living in the villages. The follow-up study took place in 2014, three months after the intervention and in the same season as the baseline study, and 316 of the participants could be interviewed a second time. The most common reasons for drop-out were that the household had moved away, or that the participant had divorced and moved out of the household. Prior to the baseline survey, 10 social workers and students were trained for eight days in use of the questionnaire, bias issues, and social skills to be interviewers. Practical training included mock interviews and a pretest. Before the follow-up survey, these 10 were retrained for one week with two new recruits to form a team of 12. Interviewees gave informed consent to participate in the study orally because of low literacy and the interviewers documented consent. Ethical approval was given by the Burundian authorities and the authors' affiliated university.

Measures

A structured questionnaire was developed in French and English and translated from French to the local language Kirundi. It was then retranslated to French for verification. During the interviewer training, the translation was rechecked question by question. The questionnaire contained variables to be self-reported, such as the behavior and psychosocial variables, and variables to be measured by short observations, such as latrine cleanliness and the quality of latrine construction. We measured psychosocial variables quantitatively as proposed by the RANAS approach (Mosler, 2012) and used 5-point scales for unipolar questions and 9-point scales for bipolar questions (Table 8). We used two questions to measure habitual latrine

cleaning. Psychosocial variables were measured with one question per variable, with the exception of *perceived severity self* (Cronbach's $\alpha = .73$ at baseline; Cronbach's $\alpha = .81$ at follow-up).

Observed latrine cleanliness was measured by a short observation on a 3-point scale (-1 = dirty, fecal material was on the slab; 0 = average, some dirt but no fecal material was on the slab; 1 = clean, slab was free of visible dirt). The interviewers also used short observations to rate the quality of latrine construction. They checked five characteristics of the latrine: whether its slab was built of wooden planks or cement (in contrast to lower quality materials like wooden sticks covered with earth), whether it had a lid on the slab hole, whether it had a door, whether the superstructure was built of clay or lower-quality material such as banana leaves), and whether the superstructure was at least as high as an adult male.

To assess socio-economic status, we used a method devised by Rutstein and Johnson (2005) and counted five assets from the Demographic and Health Surveys wealth index: whether a household has electricity, a radio, a bicycle, a cell-phone, and a roof made of corrugated iron or tiles. We then calculated a factor analysis and used each variable's weight on the first factor extracted to calculate a weighted composite index.

Table 8. Psychosocial variables

Factor block	Variable Name	Wording	Scale[a]
Behavior	Habitual latrine cleaning (2 questions)	How often do you clean the latrine?	5 pts.
		To what extent do you feel that you clean the latrine as a matter of habit?	5 pts.
Risk	Perceived vulnerability self	How high do you feel is the risk that you get diarrhea?	5 pts.
	Perceived vulnerability child	How high do you feel is the risk that your child gets diarrhea?	5 pts.
	Perceived severity self (4 questions)	Imagine you contracted diarrhea; how severe would that be - for your life in general? - for your social life? - for your economic situation?	5 pts.
		Imagine your child contracted diarrhea; how severe would that be?	5 pts.
Attitudes	Satisfaction with cleanliness	How satisfied are you with the average cleanliness of the latrine?	5 pts.
	Instrumental beliefs: effort	Do you think that cleaning the latrine is effortful?	5 pts.
	Instrumental beliefs: cost-benefit	Considering all the benefits and efforts related to cleaning the latrine, how much do you think is it worthwhile for you to clean the latrine?	9 pts.
	Instrumental beliefs: health	How certain are you that cleaning the latrine prevents you from getting diarrhea?	5 pts.
	Liking to clean	How much do you like or dislike cleaning the latrine?	9 pts.
	Disgust in cleaning	Do you think it is disgusting to clean the latrine?	5 pts.
	Disgust using dirty latrine	Do you think it is disgusting to use a dirty latrine?	5 pts.
Norms	Descriptive norm	How clean are the other latrines in your community?	5 pts.
	Injunctive norm	People who are important to you, do they rather think you should or you should keep the latrine clean?	9 pts.
	Personal norm	Do you feel a personal obligation to clean the latrine?	5 pts.
Abilities	Self-efficacy	Do you think you are always able to keep the latrine clean?	5 pts.
	Perceived behavioral control	How difficult is it to always keep the latrine clean?	5 pts.
	Maintenance self-efficacy	How confident are you that you can clean the latrine even if you have a lot of other things to do or even if you don't feel like cleaning it?	5 pts.
	Recovery self-efficacy	Imagine you have stopped cleaning the latrine for a long time. How confident would you be to start over?	5 pts.
	Cleaning with water	How do you clean your latrine? (interviewee mentions water)	2 pts.
	Cleaning with broom	How do you clean your latrine? (interviewee mentions broom)	2 pts.
Self-regulation	Coping planning	Do you have a plan to ensure that the latrine is always kept clean and what is it?	2 pts.
	Forgetting	How often does it happen that you forget to clean the latrine?	5 pts.
	Commitment strength	Do you feel committed to cleaning the latrine?	5 pts.

[a] Variables with a scale of five pts. range from 0 to 4 (0 = not at all; 4 = very much); variables with a scale of nine pts. from -4 to 4 (-4 = not at all; 4 = very much); variables with a scale of two pts. from 0 to 1 (0 = no; 1 = yes).

Intervention

Results from the baseline survey suggested that an intervention would be most successful if it emphasized the satisfaction one would derive from having a clean latrine and strengthened self-efficacy and the commitment to cleaning the latrine regularly. Detailed results are published elsewhere. Local health volunteers were trained over four days and received a detailed manual in the local language, Kirundi. From July to August 2014, they visited groups of neighbors, about three to six households at a time, to promote regular cleaning of the latrine and the improvement of the quality of latrine construction. Households were encouraged to improve the construction of their latrines by their own means and with locally available material. To increase habitual latrine cleaning the intervention aimed at two psychosocial factors, *satisfaction with latrine cleanliness* and *commitment strength*. To target satisfaction, the health workers encouraged a discussion about the satisfaction of having a clean latrine. To strengthen commitment strength, the participants could commit themselves at the end of the visit to regular cleaning and would receive a poster as a sign of their commitment. The intervention took place in two of the municipalities, in four villages. Health volunteers were instructed to visit all households in a village and were blind to which households were part of the study. They were supervised by the municipality's health worker and documented, for instance, the number and names of households visited in a day. The two villages of the third municipality, formed the control group. In these two villages, theater plays about the importance of improving latrine construction and latrine cleaning was performed as standard control intervention.

Statistical analysis

All analyses were calculated using IBM SPSS Statistics 23. We compared the households in the four villages with visits (the intervention group, $N = 198$) to the households in the two villages that had no visits (the control group, $N = 91$).

To test whether the intervention led to improved habitual latrine cleaning, we first calculated dependent t-tests for both groups separately to analyze whether the groups changed over time. Then, we calculated a repeated-measures analysis of variance (ANOVA) to test whether there was an interaction effect of group and time, thus analyzing whether the intervention group changed differently over time compared to the control group.

To test whether the intervention led to improved observed latrine cleanliness or to improved quality of latrine construction, we used non-parametric tests. First, we calculated the Wilcoxon sign-rank test for each group to analyze changes within the groups separately. Second, we computed variables which showed changes over time for each household (-1 = household worsened; 0 = household stayed the same; 1 = household improved). We used the Mann-Whitney U test to compare changes over time between the two groups.

To test whether improved quality of latrine construction led to improved observed latrine cleanliness, we looked at the whole sample, of both intervention and control group. However, households whose latrine was already rated as clean at baseline were excluded, because they could not improve any more. This gave a sample of $N = 203$. First, we computed new variables for whether a characteristic of the quality of latrine construction or observed cleanliness improved (0 = stayed the same or worsened; 1 = improved). Then we calculated chi-square tests for the new variables to compare improvements of the quality of latrine construction to observed latrine cleanliness.

To test whether the intervention influenced psychosocial factors, we used repeated-measures ANOVA. *F* values are indicated for group, time, and time by group. A significant *F* value for group means that the two groups differ in that psychosocial factor. A significant *F* value for times means that a psychosocial factor changes over time. The most important *F* value is that for the interaction of time and group. It indicates whether the two groups changed differently over time in a psychosocial factor. If the interaction effect is significant, we assume that the intervention influenced this psychosocial factor. Due to multiple testing, we adjusted the significance level with the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995).

To analyze how well changes in psychosocial factors could explain changes in habitual latrine cleaning, we used the sample as a whole again. To have a variable that represents change over time the values of habitual latrine cleaning and psychosocial variables at baseline were subtracted from the values at the follow-up. We calculated a multiple regression analysis with changes in psychosocial factors to predict changes in habitual latrine cleaning.

Last, we calculated a multiple mediation analysis to assess whether the effect of the intervention on changes in habitual latrine cleaning was mediated by changes in psychosocial factors. We applied the multiple mediation model according to Hayes (2013) using the 'PROCESS' macro.

The continuous variables used in the analyses were normally distributed and had independent and normally distributed errors. The assumptions of homogeneity of variance and linearity were met for the repeated-measures ANOVA. The assumptions of homoscedasticity and multicollinearity were met for the regression analysis.

Results

Descriptive statistics

Nearly all participants were farmers subsisting on their own land and livestock (98%). Most of them were either Catholic (48%) or Protestant (43%). All interviewees were female, mostly married (87%), and their mean age at the follow-up survey was 34.7 years (SD = 8.7; range 20 to 73). In the intervention group, the mean number of people living in a household was 6.1 (SD = 1.87; range 2 to 11), whereas in the control group the mean was 7.5 (SD = 2.87; range 2 to 16) people per household. Literacy was rather low. In the intervention group, 44% of the interviewees reported being able to read and write compared to 60% in the control group. The socio-economic status ranged from 0 to 3.08 on the weighted composite index; the mean was 1.29 (SD = 0.85) in the intervention group and 1.68 (SD = 0.75) in the control group. In the control group, only 16 respondents (18 %) reported having seen the theatre play about latrines. There were no statistically significant differences between households who had seen the theater play and those who had not seen it regarding habitual latrine cleaning, observed latrine cleanliness, or the quality of latrine construction. We therefore decided not to exclude any households from the control group.

Habitual latrine cleaning and latrine cleanliness

Generally, the means for observed latrine cleaning and habitual latrine cleaning were mediocre (Table 9). For example, the mean of 2.51 in the intervention group at baseline indicates that participants cleaned their latrine about twice a week and reported a medium to strong habit of cleaning.

The intervention group did not change in habitual latrine cleaning, $t(197) = 0.12$, $p = .91$. The control group decreased in habitual latrine cleaning, $t(90) = 2.78$, $p = .007$. The effect size of this change was small, $r = .28$. A repeated-measures ANOVA revealed a significant effect of group, $F(1) = 27.45$, $p < .001$ and of time, $F(1) = 4.82$, $p = .03$. Thus, the groups differed, and they changed over time. Most importantly, there was a significant interaction effect of time and group, $F(1) = 4.24$, $p = .04$. Hence, the groups changed differently over time: whilst the intervention group remained stable, the control group decreased in habitual latrine cleaning.

Table 9. Habitual latrine cleaning and observed latrine cleanliness in intervention and control group at baseline and follow-up

	Intervention group			Control group		
Habitual latrine cleaning	M		SD	M		SD
Baseline	2.51		1.07	3.25		0.51
Follow-up	2.50		1.21	2.93		1.07
Observed latrine cleanliness	dirty	med.	clean	dirty	med.	clean
Baseline	34%	45%	21%	8%	55%	37%
Follow-up	21%	48%	31%	14%	59%	27%

med. = mediocre

Regarding observed latrine cleanliness, the Wilcoxon sign-rank test revealed an increase in the intervention group from baseline to follow-up, Z = -3.00, p = .003, r = .23. There was no significant change in the control group, Z = -1.58, p = .11. In the intervention group, 25% of households worsened, 37% stayed the same, and 39% improved in their observed latrine cleanliness. In the control group, 36% of households worsened, 40% stayed the same and 24% improved in their observed latrine cleanliness. Comparisons with Mann-Whitney U test shows that households in the intervention group were significantly more likely to improve than households in the control group, U = 6000, z = 2.42, p = .02. However, the size of this effect is small, r = .15.

The quality of latrine construction

The quality of latrine construction was mostly low. Chi-square tests showed that quality of latrine construction increased in four of the five characteristics in the intervention group, all except the lid on the slab hole. In the control group, the quality of latrine construction increased in two of the characteristics, and decreased in one characteristic (Table 10).

Table 10. Chi-square tests for characteristics of the latrine at baseline and follow-up in the intervention and the control group

Variable	Intervention group			Control group		
	Baseline	Follow-up	$\chi^2(1)$	Baseline	Follow-up	$\chi^2(1)$
Slab is of wooden planks or cement	15%	23%	18.67***	36%	46%	9.19**
Lid covers slab hole	5%	9%	2.79	9%	0%	n.a.
Door is available	9%	9%	20.97***	21%	12%	8.80**
Material of superstructure is made of clay	30%	38%	49.91***	66%	64%	5.46*
Superstructure is as high as an adult male	30%	54%	21.00***	60%	68%	0.04

**p < .005; ***p < .001

A comparison with the Mann-Whitney U test showed that households in the intervention group were more likely than those in the control group to improve in having a lid covering the latrine slab, $U = 2629$, $z = -2.09$, $p = .04$, $r = .15$, and the height of the superstructure, $U = 5128$, $z = -2.05$, $p = .04$, $r = .13$. The small effect sizes should be noted.

Influences on improved observed latrine cleanliness

We calculated chi-square tests to determine whether improved habitual latrine cleaning and improved quality of latrine construction led to improved observed cleanliness (Table 11). There was a significant association between improved habitual latrine cleaning and improved observed latrine cleanliness. The odds of a household's latrine cleanliness being improved were 3.48 times higher if the household had improved habitual latrine cleaning. Further, households that had improved their latrines with a lid on the slab hole were 7.39 times more likely to have improved latrine cleanliness, and households that had improved the material of the superstructure were 2.80 times more likely to have improved latrine cleanliness. In addition, there was a marginal effect for households that had installed a door on the latrine being 3.26 times more likely to have improved latrine cleanliness.

Table 11. Chi-square tests for improved quality of latrine construction and improved observed latrine cleanliness

	Latrine cleanliness not improved		Latrine cleanliness improved		
Variable improved:	n	%	n	%	$\chi^2(1)$
Habitual latrine cleaning	27	28%	49	57%	16.36***
Slab is of wooden planks or cement	15	16%	13	15%	0
Lid covers slab hole	1	1%	6	10%	4.46*
Door is available	3	3%	8	10%	3.20†
Material of superstructure is made of clay	11	12%	23	27%	6.84**
Superstructure is as high as an adult male	24	28%	29	38%	1.63

†p < .1; *p < .05; **p < .005; ***p < .001

Means and changes of psychosocial factors

We calculated a repeated-measures ANOVA for the psychosocial factors in the two groups to investigate whether there were effects of effects of time, group or what we are most interested in, the interaction of time and group (Table 12). The only significant interaction effect we found was for *disgust in cleaning the latrine*. Households in the intervention group developed differently in the disgust they felt while cleaning compared to the control group. A comparison of the means shows, that in the intervention group disgust decreased, whereas in the control group disgust increased. There was a marginal interaction effect for *descriptive norm*. *Descriptive norm* decreases over time, but it decreases more in the control group than in the intervention group

Table 12. Means for intervention and control group at baseline and follow-up, F-values from the repeated measures ANOVA for group and time and time by group

	Intervention group			Control group			ANOVA $F(1)$		
Variable	Baseline	Follow-up	Diff.	Baseline	Follow-up	Diff.	Group	Time	Time*Group
Perceived vulnerability self	1.21	1.62	0.41	1.21	1.45	0.24	1.07	21.87***	1.45
Perceived vulnerability child	2.89	2.07	-0.82	2.88	2.16	-0.71	0.12	48.97***	0.23
Perceived severity self	3.69	3.65	-0.02	3.64	3.27	-0.37	0.89	76.91***	0.00
Satisfaction with cleanliness	2.46	2.46	0.01	2.78	2.53	-0.25	4.30†	2.40	2.60
Instrumental beliefs: effort	0.74	1.14	0.39	0.52	1.22	0.70	0.34	27.75***	2.21
Instrumental beliefs: cost-benefit	2.99	3.12	0.13	3.11	3.47	0.36	7.62*	11.47**	2.50
Instrumental beliefs: health	1.14	1.79	0.65	1.21	1.71	0.51	0.00	46.99***	0.73
Liking to clean	2.32	2.37	0.05	2.87	2.99	0.12	19.26***	0.55	0.11
Disgust in cleaning	1.22	1.13	-0.10	0.95	1.49	0.55	0.12	3.29	6.66*
Disgust using dirty latrine	3.37	3.64	0.27	3.42	3.74	0.32	1.39	25.13***	0.15
Descriptive norm	1.98	1.87	-0.11	2.26	1.84	-0.41	3.11	14.57***	4.81†
Injunctive norm	2.74	1.97	-0.77	2.46	1.64	-0.82	5.70†	40.32***	0.05
Personal norm	2.80	2.66	-0.14	3.14	2.96	-0.19	11.19**	4.12	0.10
Self-efficacy	2.30	2.22	-0.08	2.66	2.29	-0.37	3.89	7.30*	3.03
Perceived behavioral control	0.93	1.16	0.23	0.62	0.98	0.36	4.08	9.34*	0.45
Maintenance self-efficacy	2.86	2.65	-0.21	2.96	2.81	-0.14	3.18	8.99*	0.30
Recovery self-efficacy	3.08	2.76	-0.32	3.13	2.87	-0.26	1.29	22.73***	0.20
Cleaning with water	0.20	0.11	-0.09	0.62	0.43	-0.19	100.71***	15.43***	1.95
Cleaning with broom	0.68	0.67	-0.01	0.97	0.92	-0.04	46.21***	0.54	0.34
Coping planning	0.54	0.88	0.35	0.73	0.87	0.14	0.31	3.26	0.27
Forgetting	1.38	1.47	0.09	0.82	1.15	0.33	15.14***	6.35†	2.046
Commitment strength	2.71	2.68	-0.03	3.01	2.89	-0.12	8.26*	1.17	0.42

Note. Significance values were adjusted due to multiple testing according to the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995). $p \leq .02916$ corresponds to $p < .1$; $p \leq .01038$ corresponds to $p < .05$; $p \leq .00093$ corresponds to $p < .005$; $p \leq .00017$ corresponds to $p < .001$. Diff. = difference from baseline to follow-up: value at follow-up - value at baseline.

† $p \leq .02916$; * $p \leq .01038$; **$p \leq .00093$; ***$p \leq .00017$

Effects of changes in psychosocial factors on changes in habitual latrine cleaning

Table 13 displays results of a multiple regression of changes in psychosocial factors predicting changes in habitual latrine cleaning. There was no need to include control variables such as household size, literacy and socio-economic status, or changes in socio-economic status as none of these correlated with changes in habitual latrine cleaning. Psychosocial factors were able to explain much of the variance of changes in habitual latrine cleaning (adj. r^2 = .46). Changes in seven psychosocial factors were significant predictors for changes in habitual latrine cleaning. The strongest were *forgetting* (β = -.26), *personal norm* (β = .18), *commitment strength* (β = .17), and *satisfaction with cleanliness* (β = .16).

Table 13. Multiple regression of changes in psychosocial factors predicting changes in habitual latrine cleaning

Changes over time in	*B*	*SE B*	*β*	*t*	*p*
(Constant)	-0.07	0.09		-0.77	0.44
Perceived vulnerability self	0.04	0.05	0.03	0.70	0.49
Perceived vulnerability child	0.01	0.03	0.02	0.42	0.67
Perceived severity self	**-0.19**	**0.08**	**-0.11**	**-2.30**	**0.02**
Satisfaction with cleanliness	**0.15**	**0.05**	**0.16**	**3.08**	**0.00**
Instrumental beliefs: effort	0.03	0.04	0.04	0.76	0.45
Instrumental beliefs: cost-benefit	0.08	0.05	0.08	1.51	0.13
Instrumental beliefs: health	-0.01	0.04	-0.01	-0.21	0.84
Liking to clean	**0.08**	**0.04**	**0.12**	**2.21**	**0.03**
Disgust in cleaning	0.00	0.03	0.00	-0.04	0.97
Disgust using dirty latrine	0.03	0.06	0.02	0.43	0.67
Descriptive norm	0.04	0.05	0.04	0.85	0.39
Injunctive norm	0.03	0.03	0.05	1.03	0.30
Personal norm	**0.17**	**0.05**	**0.18**	**3.49**	**0.00**
Self-efficacy	-0.01	0.05	-0.01	-0.18	0.86
Perceived behavioral control	0.01	0.04	0.01	0.21	0.84
Maintenance self-efficacy	-0.07	0.08	-0.05	-0.80	0.42
Recovery self-efficacy	**0.17**	**0.07**	**0.14**	**2.34**	**0.02**
Cleaning with water	0.09	0.10	0.04	0.88	0.38
Cleaning with broom	0.10	0.10	0.05	1.01	0.32
Coping planning	0.13	0.11	0.06	1.24	0.22
Forgetting	**-0.23**	**0.06**	**-0.26**	**-4.16**	**0.00**
Commitment strength	**0.18**	**0.06**	**0.17**	**2.89**	**0.00**

Adj. r^2 = .46, bold: significant effects.

Mediation by psychosocial factors on the effect of the intervention on habitual latrine cleaning

We computed a mediation model to assess whether the effect of the intervention on habitual latrine cleaning was mediated by psychosocial factors. We included those psychosocial factors as possible mediators for which the repeated-measures ANOVA had revealed interaction effects (*disgust in cleaning* and *descriptive norm*) and those which had been predictors of change in habitual latrine cleaning in the multiple regression (*perceived severity self, satisfaction with cleanliness, liking to clean, personal norm, recovery self-efficacy, forgetting* and *commitment strength*). Those nine psychosocial factors were included in a mediation model as parallel mediators.

The results are displayed in Table 14. The a-path reveals which psychosocial factors were affected by the intervention. These were the same ones for which interaction effects were found in the repeated-measures ANOVA: *disgust in cleaning* and *descriptive norm*. The b-path shows which psychosocial factors influenced change in habitual latrine cleaning. These were the same as in the multiple regression. The indirect path is the multiplication of the a- and b-paths. It was only significant for the psychosocial factor *satisfaction with cleanliness*. However, the small effect shows that *satisfaction with cleanliness* only mediates a very small part of the intervention effect. Overall, there was no significant total indirect effect. The direct effect of the intervention on changes in habitual latrine cleaning was marginally significant (p = .08). The total effect, which is the sum of the total indirect effect and the direct effect, was significant (p = .03). For the most part, the psychosocial factors did not mediate the effect of the intervention.

Table 14. Multiple mediation results regarding changes in habitual latrine cleaning: comparing the intervention group to the control group

Mediator	Intervention: a path			Change in habitual latrine cleaning: b path			Indirect effect (95% CI)		
	B	SE	*p*	*B*	SE	*p*	LL	*B*	UL
Perceived severity self	-0.01	0.09	0.94	**-0.17**	**0.08**	**0.03**	-0.03	0.00	0.03
Satisfaction with cleanliness	0.27	0.16	0.09	**0.15**	**0.05**	**0.00**	**0.00**	**0.04**	**0.12**
Liking to clean	-0.07	0.22	0.74	**0.09**	**0.04**	**0.01**	-0.07	-0.01	0.02
Personal norm	0.10	0.16	0.54	**0.16**	**0.05**	**0.00**	-0.02	0.02	0.09
Recovery self-efficacy	-0.06	0.12	0.64	**0.18**	**0.06**	**0.00**	-0.08	-0.01	0.03
Forgetting	-0.23	0.17	0.17	**-0.24**	**0.05**	**0.00**	-0.01	0.06	0.16
Commitment strength	0.09	0.14	0.52	**0.17**	**0.06**	**0.00**	-0.03	0.02	0.07
Disgust in cleaning	**-0.06**	**0.25**	**0.01**	0.01	0.03	0.76	-0.06	-0.01	0.04
Descriptive norm	**0.30**	**0.14**	**0.03**	0.06	0.05	0.20	-0.01	0.02	0.07
Total indirect effect							-0.07	0.12	0.36
Direct effect							-0.02	0.20	0.42
Total effect							**0.03**	**0.32**	**0.62**

CI confidence interval; *B* unstandardized regression coefficient; *SE* standard error; LL lower limit, UL upper limit, Indirect effects were calculated by bootstrapping (1000 bootstraps; bold: significant effects).

Discussion

This study evaluated the effects of an intervention based on the RANAS approach on habitual latrine cleaning, observed latrine cleanliness and the quality of latrine construction. Specifically, we analyzed how the intervention affected psychosocial factors and how those in turn affected behavior. Moreover, we analyzed how improved quality of latrine construction influenced its cleanliness.

Latrines were cleaner after the intervention. There was an improvement in observed latrine cleanliness in the intervention group and no change in the control group. Surprisingly, habitual latrine cleaning did not increase; there was no change in the intervention group and a decrease in the control group. This inconsistency between the development of the observed latrine cleanliness and self-reported habitual latrine cleaning could be explained by assuming that, after being interviewed at the baseline survey, the respondents started to self-observe their behavior more carefully and realized that they actually cleaned less frequently than they had thought. By the time of the follow-up survey, they would then have been able to report their behavior more accurately. Indeed, a study on over-reporting of handwashing behavior showed that over-reporting was caused by inaccurate memorizing and recall and not only by social desirability (Contzen, De Pasquale, et al., 2015).

Both groups improved many characteristics of their latrine construction. The intervention group was slightly more likely than the control group to improve the latrine by putting a lid on the drop hole or by building a superstructure which was at least as high as an adult male. Overall, it seems that the intervention had only some small effects on the quality of latrine construction. One reason could be that men, who usually make the decision to build a latrine, were often not present during the promotional visit. It proved very difficult for the local health volunteers to find both spouses at home together, and they often conducted the intervention session with the men absent, even though we had planned for men to be included as well.

Improved quality of latrine construction led to higher cleanliness. Households that improved their latrine between the baseline and the follow-up survey by putting a lid on the drop hole, by building a superstructure from a more stable material, or by installing a door were also more likely to improve in observed latrine cleanliness. The availability of a door and the material of the superstructure had already been found to be correlated with observed latrine cleanliness at

baseline. Other studies have found correlates of lid on the drop hole, availability of a door, superstructure material, and height with latrine cleanliness (Diallo et al., 2007; Kwiringira, Atekyereza, Niwagaba, & Günther, 2014; Tumwine et al., 2003). To the best of our knowledge, this is the first longitudinal study showing the influence of the quality of latrine construction on cleanliness. Latrines of better construction quality are probably easier or less unpleasant to clean. Additionally, users may be more likely to take more care when using a well-built latrine. Beyond the quality of latrine construction, improved habitual latrine cleaning was a very strong predictor of higher latrine cleanliness. Households that increased in habitual latrine cleaning were more than three times more likely to also improve latrine cleanliness. This is an important finding, as the reliability and validity of self-reported hygiene behaviors have been questioned (Manun'Ebo et al., 1997; Ram, 2013). In addition, respondents have control over latrine cleanliness; the situation improves when they change their behavior.

Socio-economic status did not influence improvements in observed latrine cleanliness or habitual cleaning behavior. Thus, the intervention reached the participants irrespective of their socio-economic status. Other promotions often have the problem of being more successful in reaching higher income groups than lower income groups (e.g. Bajracharya, 2003; Luby et al., 2004). However, it should be noted that our sample was relatively homogenous in socio-economic status.

Interventions using the RANAS approach determine the psychosocial factors influencing a behavior and then aim specifically at these to change the behavior. Therefore, we analyzed how the intervention influenced psychosocial factors. Surprisingly, differences between the intervention and the control group were small, and they only developed differently in two psychosocial factors, *disgust in cleaning the latrine* and *descriptive norm*. The RANAS approach also assumes that behavior change is caused by changes in psychosocial factors. Indeed, nearly half of the variance in change of habitual latrine cleaning in our study was explained by changes in psychosocial factors. Correspondingly, studies using psychosocial factors from the RANAS approach to evaluate behavior change have been able to explain changes in cleaning of shared latrines in Kampala slums (Tumwebaze & Mosler, 2015), changes in handwashing behavior in Ethiopia (Contzen & Inauen, 2015), and switching to arsenic-safe wells in Bangladesh (Inauen & Mosler, 2014). In our study, we found that the most important predictors were changes in *forgetting*, *personal norm*, *commitment strength*, and *liking to clean*. Remembering or not forgetting is fundamental for habit formation (Tobias,

2009). Personal norm and commitment strength are very similar. Individuals who are committed to a behavior feel pressure to perform that behavior because otherwise they feel they would be inconsistent (Tobias, 2009). In a recent meta-analysis, commitment-making strategies were found to be efficient in changing behavior (Lokhorst, Werner, Staats, van Dijk, & Gale, 2013). Satisfaction has been found to be important in the context of willingness to pay for safe sanitation (Tumwebaze, Orach, Niwagaba, Luthi, & Mosler, 2013; Van Minh et al., 2013). Correspondingly, pride and dignity, which are similar feelings to satisfaction, were reported to be very important in changing behavior in the community-led total sanitation approach whose aim is to end open defecation (Lawrence et al., 2016).

Notably, the predictors of change in habitual latrine cleaning were not those that we found had been influenced by the intervention. This was also reflected in the results of the mediation model. We found small mediating effects for the psychosocial factor *satisfaction with cleanliness*, but most of the total effect from the intervention on behavior was a direct effect and not an indirect one over psychosocial factors. Thus, we do not know how the intervention caused behavior to change only that for most part it was not because of psychosocial factors. In other words, the intervention did psychologically not work the way we had intended it to. Other studies using the RANAS approach have been successful in explaining behavior change with psychosocial factors (Contzen, Meili, et al., 2015; Huber et al., 2014). However, in one evaluation of three different interventions that successfully promoted switching to arsenic-safe wells in Bangladesh, only two of the interventions could be explained by psychosocial factors in the RANAS approach; the success of one intervention could not be explained by psychosocial factors (Inauen et al., 2014). More research is needed on the reasons underlying the success and failure of interventions on water and sanitation; this is especially the case because most research to date has only looked at success without considering psychosocial factors.

Limitations

One limitation of the study is the rather long time lag of over a year between the baseline survey and the start of the interventions. They had to be delayed several times due to logistical problems. Many events other than the intervention might have occurred between the two surveys that could have influenced changes to habitual latrine cleaning and the quality of latrine construction. Further, the control group was not ideal, for two reasons. First, the control group differed at baseline from the intervention group in some variables. The control group had higher

socio-economic status, habitual latrine cleaning, observed latrine cleanliness, and the quality of latrine construction. Thus, the groups are not completely comparable. However, the longitudinal study did not compare the groups directly but compared changes within groups. Second, we had planned to compare the intervention using the RANAS approach to a standard control intervention. To show that a new intervention is effective, it should not only be able to change behavior but also be more effective in doing so than an existing intervention. Therefore, we planned an intervention using a theater play as control. Unfortunately, only 18% of the respondents in the control group had seen the play, so we cannot claim that we compared the intervention using the RANAS approach to a standard intervention. We did not exclude any respondents from the control group, as those who had seen the play and those who had not did not differ from each other.

Conclusion

The Sustainable Development Goals' call for adequate sanitation for all entails ensuring the hygiene and cleanliness of sanitation facilities. Knowledge about how to improve cleanliness is thus fundamental for practitioners. We demonstrated that improved habitual latrine cleaning led to improved latrine cleanliness. Cleanliness also improved if the quality of latrine construction improved, probably because it was easier to maintain. However, we would not recommend basing an intervention only on this effect, because we believe it is unlikely that a latrine's cleanliness could be ensured purely by improving the quality of its construction. On the contrary, many examples show that the mere provision of infrastructure leads to abandoned, dirty, and unused facilities if not accompanied by behavior change interventions (Mara, Lane, Scott, & Trouba, 2010; Peal, Evans, & van der Voorden, 2010). Results were mixed regarding the effectiveness of the RANAS approach in explaining behavior and designing an intervention. While the intervention improved latrine cleanliness, it remained unclear how this change happened; there was little evidence for it happening through changes in the psychosocial factors proposed by the model. However, irrespective of the intervention, our results also showed that changes in behavior were caused by changes in psychosocial factors. Behavior change happens through change in psychosocial factors, and research should continue to find ways to influence these and to evaluate the reasons for the success and failure of interventions.

Chapter IV

Spot-checks to measure general hygiene practice

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Abstract

A variety of hygiene behaviors are fundamental to the prevention of diarrhea. We used spot-checks in a survey of 761 households in Burundi to examine whether something we could call *general hygiene practice* is responsible for more specific hygiene behaviors, ranging from handwashing to sweeping the floor. Using structural equation modeling, we showed that clusters of hygiene behavior, such as primary caregivers' cleanliness and household cleanliness, explained the spot-check findings well. Within our model, general hygiene practice as overall concept explained the more specific clusters of hygiene behavior well. Furthermore, the higher general hygiene practice, the more likely children were to be categorized healthy (r = .46). General hygiene practice was correlated with commitment to hygiene (r = .52), indicating a strong association to psychosocial determinants. The results show that different hygiene behaviors co-occur regularly. Using spot-checks, the general hygiene practice of a household can be rated quickly and easily.

Keywords: Behavior Change; Hygiene Behavior; Spot-Checks; Modeling; Diarrhea

Introduction

Of 1.5 million deaths related to diarrhea in 2012, it is estimated that 842,000 were caused by inadequate water, sanitation, and hygiene (Wolf et al., 2014). Hygiene alone is estimated to reduce diarrhea morbidity by up to 45% (Fewtrell et al., 2005). According to the World Health Organization, the term *hygiene* refers to conditions and practices that help to maintain health and prevent the spread of diseases (World Health Organization, n.d.). Risk factors for hygiene include poor personal, domestic, and agricultural hygiene as transmission pathways (Prüss, Kay, Fewtrell, & Bartram, 2002). Consequently, hygiene includes a broad range of behaviors, such as cleaning water containers, handwashing, and keeping household courtyards free of animal feces. This diversity can present a problem for disease prevention practitioners, who are confronted with a large number of different behaviors; it can be difficult to know whether a behavior change campaign should tackle them all simultaneously or whether a more specific focus is preferable.

Few studies have examined how different hygiene behaviors are interrelated. Bartlett et al. (1992) found strong correlations between different hygiene indicators. In a study of hygiene behaviors in Botswana, Kaltenthaler and Dražar (1996) reported that certain behaviors seemed to cluster. Webb et al. (2006) grouped hygiene indicators into four domains: drinking water cleanliness, domestic household cleanliness, food hygiene, and personal hygiene. This grouping of behaviors indicates that some hygiene behaviors are similar and more closely related than others are. Based on these studies and building upon the impression that certain households are very clean and hygienic in general, whereas others are not, we questioned whether the numerous hygiene behaviors indeed differ, or whether they represent the expression of a single practice. We hypothesize that they are all the expression of a single practice and ask whether something we could call *general hygiene practice* explains all kinds of hygiene behaviors. We propose to define general hygiene practice, as a consistent approach that influences all daily routines and behaviors related to hygiene.

As a health behavior, general hygiene practice would be influenced by different psychosocial determinants. Several behavior change theories describe the influence of psychosocial determinants on health behavior. (e.g., theory of planned behavior [Ajzen, 1991]; the health belief model [Rosenstock, 1974]; the risk, attitude, norms, abilities and self-regulation model [RANAS; Mosler, 2012]). One psychosocial determinant that seems to play a crucial role in developing countries is commitment. Tobias (2009) postulates that commitment is an internal pressure felt by a person to perform a behavior. It has been found to be a predictor of safe water

use in Bangladesh (Inauen et al., 2014), Ethiopia (Huber & Mosler, 2013), and Vietnam (Tobias, 2009) and of latrine cleaning in Burundi (Sonego & Mosler, 2014) and Uganda (Tumwebaze et al., 2014). Therefore, commitment is one of the psychosocial determinants that is most likely to be related to general hygiene practice.

In order to conduct research on hygiene behaviors they have to be measured which is a challenge. Several methods are currently used. Self-reports, though fast and easy to measure, have the disadvantage that respondents tend to over-report behavior (Halder et al., 2010; Ram, 2013). Structured observations are often considered the gold standard but are very costly and time consuming, and they can be reactive as well (Gittelsohn, Shankar, West Jr, Ram, & Gnywali, 1997). Spot-checks are short observations during which an observer fills out a checklist about the conditions he or she encounters. They do not measure hygiene behavior directly but serve as proxies (e.g., the cleanliness of the floor serves as a proxy for floor cleaning). They have the advantage that they are quick and easy to use and, especially if unannounced, less prone to bias due to over-reporting than self-report (Ruel & Arimond, 2002).

The present study

We conducted a cross-sectional study on hygiene behaviors in three rural provinces in Burundi. We used spot-checks, structured observations, and interviews to assess hygiene behaviors. The study aimed to answer four research questions.

3.1 Does the construct we have termed general hygiene practice explain all kinds of hygiene behaviors?

To answer this question, we analyzed whether a range of different hygiene behaviors were independent or related to each other. We also assumed that hygiene can be differentiated into several clusters. Similar behaviors within the same cluster would be more closely related then behaviors from different clusters. We assumed that the following thematic clusters would occur: the primary caregiver's personal hygiene, child's hygiene, household cleanliness, cleanliness related to animals, cleanliness of water containers, and cleanliness of the latrine. To analyze general hygiene practice, we used spot-checks only.

3.2 Is general hygiene practice, measured with spot-checks, related to hygiene behaviors that are measured with self-report or structured observations?

To compare different methods used to measure hygiene behaviors, we analyzed how general hygiene practice measured with spot-checks relates to other methods often used to assess hygiene behaviors.

3.3 Does general hygiene practice relate to commitment to hygiene behaviors?

We wanted to test the influence of a psychosocial factor to see whether general hygiene practice is influenced by it as other hygiene behaviors often are. We chose commitment from all the psychosocial determinants possible, because a substantial quantity of research has shown its important role in health behavior in developing countries (e.g. Huber & Mosler, 2013; Tobias, 2009).

3.4 Is general hygiene practice related to health outcomes?

We further investigated whether general hygiene practice is related to child health. Indeed, several studies have found a relationship between hygiene behaviors measured by spot-checks and child diarrhea morbidity. In a review of studies on hygiene spot-checks, (Ruel & Arimond, 2002) state that all studies reviewed that tested for it, six in total, found relationships between hygiene spot-checks and diarrhea morbidity.

Methods

Research area

The study was conducted in three rural provinces of Burundi: Bururi, Kirundo, and Ruyigi (Figure 4). In each of the three provinces, two communes were randomly selected. Two villages were selected in each commune, providing a total of 12 villages.

Figure 4. Map of Burundi.

Note. Provinces where data was collected are colored green. Based on UN map (Map No. 3753, Rev. 7).

Sample and data gathering

Data collection took place in October and November 2012. The random route method was applied to select approximately 60 households per village (Hoffmeyer-Zlotnik, 2003). Therefore, interviewers chose every third household on their route and were able to walk most paths in every village. Caretakers of children under the age of five were interviewed, usually women, because children that age are the most vulnerable to illnesses. The interviewers skipped households with no children of that age. However, most households included at least one child under five. The caretakers gave informed consent to participate in the study. A total of 761 households were surveyed using structured face-to-face interviews, spot-check observations,

and structured observations. A reduced sample of 232 households was also observed for 2 hours specifically to investigate handwashing behaviors. To minimize reactivity, interviewers revealed the aim of the study only at the end of the interview, and the spot-checks were unannounced. Ten local university students and social workers were recruited as interviewers. They had all previously worked either as data collectors or as promoters. They were trained for 8 days in use of the questionnaire, bias issues, and social skills. Practical training included mock interviews and a pretest in which teams of two interviewers were built. To maximize inter-rater reliability, the interviewers were switched repeatedly so that, by the end, everyone had trained with everyone else. The team was supervised by the first author, a research assistant and a field coordinator during the complete time of the data collection. Ethical approval was given by the Burundian authorities and the authors' affiliated university.

Variables used in the analysis

The variables used for the analysis are shown in Table 15. Spot-checks were chosen from the list given in Ruel and Arimond (2002) meta-analysis. Wherever possible, the indicators were rated on a 3-point scale (*clean*, *average*, *dirty*) as proposed by Merchant and Udipi (1997). Otherwise, spot-check data were recorded as responses to yes-or-no questions, resulting in a binary scale. Fourteen spot-checks were conducted, in these six domains: the primary caregiver's personal hygiene, child's hygiene, household cleanliness, cleanliness related to animals, cleanliness of water containers, and cleanliness of the latrine. Clear instructions were given for cleanliness rating to make this as objective as possible. For example, the latrine was rated *dirty* if fecal material was on the floor, *average* if there was some dirt but no fecal material, and *clean* if the floor was clean. Child's health was also measured with two spot-checks as proxies. The interviewer observed on binary yes-or-no scales whether the child had eye discharge or nose discharge. Eye discharge can be a sign of an eye infection and nose discharge the sign of an upper respiratory tract infection.

Self-reported answers were given on a 5-point Likert scale. The psychological construct of commitment to hygiene is measured by two questions: one about commitment to handwashing and the other about commitment to cleaning the latrine. During the structured handwashing observation, the interviewer registered each critical handwashing moment, meaning each moment when the primary caregiver should have washed her hands (before contact with food and after possible contact with fecal matter) and recorded whether she actually washed her hands with soap and water or not (Scott, Curtis, & Cardosi, 2006). We calculated the proportion of times the primary caregiver washed hands at critical handwashing moments. To assess

household wealth, we calculated a composite index of nine assets from the demographic and health surveys (DHS) wealth index (Rutstein & Johnson, 2005).

Table 15. Variables used in the analysis.

Group	Variable	Wording	Scale
Spot-checks			
Child's hygiene	Nails, Child	How clean are his or her nails?	3 pt.
	Hands, Child	How clean are his or her hands?	3 pt.
	Clothes, Child	How clean are his or her clothes?	3 pt.
Primary caregiver's hygiene	Nails, Mother	How clean are her nails?	3 pt.
	Hands, Mother	How clean are her hands?	3 pt.
	Clothes, Mother	How clean are her clothes?	3 pt.
Hygiene of the household	Garbage	Is there garbage around?	3 pt.
	Floor	How clean is the floor in the house?	3 pt.
Cleanliness of water containers	Water, covered	Is the water covered?	2 pt.
	Container, outside	How clean is the outside of the water container?	3 pt.
	Container, inside	How clean is the inside of the water container?	3 pt.
Cleanliness related to animals	Animal feces	Is there animal feces in the courtyard?	2 pt.
	Animal cook	Are animals near the cooking area?	2 pt.
Cleanliness of the latrine	Latrine	How clean is the latrine?	3 pt.
Child's health	Eye discharge	Does the child have eye discharge?	2 pt.
	Nose discharge	Does the child have nose discharge?	2 pt.
Self-reported variables			
Handwashing behavior	Handwashing self-report	How often do you wash your hands with soap and water?	5 pt.
Latrine cleaning behavior	Latrine cleaning self-report	How often do you clean the latrine?	5 pt.
Commitment to hygiene	Commitment to handwashing	Do you feel committed to washing your hands with soap and water?	5 pt.
	Commitment to cleaning the latrine	Do you feel committed to cleaning your latrine?	5 pt.
Household wealth	Number of assets owned	Composite index of nine assets: whether household has radio, bicycle, mobile phone, watch, table, chair, bed, windows with glass, roof of corrugated iron/tiles	10 pt.
Observation			
Handwashing in observation	Handwashing observation	Number of times mother washed hands divided by the critical handwashing moments	n.a.

Statistical analysis

For all research questions, we calculated structural equation models with AMOS 21. The χ^2 test, comparative fit index (CFI), and root mean square error of approximation (RMSEA) were calculated to evaluate the fit of the models. For the CFI, both > .9 (Bentler, 1990; Byrne & Campbell, 1999) and > .95 (Arnold et al., 2015) have been proposed as the cut-off for adequate fit. For the RMSEA, Schermelleh-Engel, Moosbrugger, and Müller (2003) suggested values of

≤ .05 to indicate a close fit, and values between .05 and .08 to be acceptable. Arnold et al. (2015), however, simply suggested .06 as the cut-off value for acceptable fit.

To answer the question whether the construct general hygiene practice explains all kinds of hygiene behaviors, we calculated a confirmatory second-order factor analysis model (Figure 1). The spot-checks served as indicators of the hygiene domains. The primary caregiver's personal hygiene, child's hygiene, household cleanliness, cleanliness related to animals, cleanliness of water containers, and cleanliness of the latrine were the first-order factors. Correlations between the different hygiene domains and between spot-checks were generally set to zero. For the spot-checks, we added error covariance in some cases (e.g. the errors for cleanliness of the hands of the primary caregiver and cleanliness of the hands of the child covary).

Using confirmatory factor analysis, we can test the assumption that the shared variance of measurable variables (the spot-checks) can be explained by a first-order factor (the various domains of hygiene). General hygiene practice, which was the second-order factor, loaded on all first-order factors. Again, the model tests whether the shared variance of the first-order factors, the various domains of hygiene, can be explained by the second-order factor, general hygiene practice. The model was calculated with full information maximum likelihood.

To examine the questions about the relationships to three other measures of hygiene, the psychological construct commitment and child's health, we extended the model with a correlation (Figure 2). We calculated correlations of general hygiene practice with the following variables: hygiene behaviors measured differently than with spot-checks (handwashing self-report and structured observation; latrine cleaning self-report), the psychological variable, commitment to hygiene, and child's health. The correlations were rated weak if $r > .1$, medium if $r > .3$, and strong if $r > .5$ (Cohen, 2013).

All models were controlled for household wealth. To do this, the influence of household wealth (number of assets owned) on each observed variable was added to each model.

Results

Descriptive statistics

In all but three cases (0.4%), primary caregivers were female. They were mostly married (76.2%) or cohabiting (13.9%). The mean number of people living in a household was 5.89 (SD = 2.12), ranging from two to 16. Only 18% of the sample had completed primary school. Participants were mostly Catholic (57.4%) or Protestant (40.1%), and the remainder were either Muslim or atheist. Most participants (95.0%) made their living from farming and/or had livestock. The households' mean monthly income was equivalent to USD 32.6, based on the average exchange rate in October 2012. However, the high non-response rate for this question (55.0%) and the very high standard deviation (SD = 31.24) should be noted. The proxy for household wealth shows that households on average owned slightly more than four of the nine assets noted. Table 16 reports descriptives for the variables used in the model.

Generally, the mean values for the spot-checks showed poor hygiene behaviors. The mean values for child's hygiene, primary caregiver's hygiene, and household cleanliness are below zero; thus, the spot-checks were typically rated somewhere between *poor* and *average*. Cleanliness of water containers, cleanliness related to animals, and cleanliness of the latrine were rated better, usually between *average* and *good*. The correlation matrix of all spot-checks can be found in Table A7. The child health indicators show that most children did not have eye or nose discharge. The self-reported variables are rather high. The mean of the handwashing self-report, 2.67, signifies that people mostly report washing their hands 'quite often' or 'often.' One exception is commitment to handwashing, which indicates that people were only somewhat committed to handwashing. The structured handwashing observation stands in sharp contrast to the higher handwashing self-report; primary caregivers washed their hands with soap and water at only 9% of the critical handwashing moments.

Table 16. Descriptives for variables used in the models.

Variable name	N	Mean	SD	Min.	Max.
Child's hygiene					
Nails, child	759	–0.45	0.78	–1	1
Hands, child	760	–0.21	0.88	–1	1
Clothes, child	754	–0.38	0.79	–1	1
The primary caregiver's hygiene					
Nails, mother	760	–0.48	0.79	–1	1
Hands, mother	761	–0.05	0.92	–1	1
Clothes, mother	761	–0.19	0.81	–1	1
Household cleanliness					
Garbage	758	–0.17	0.91	–1	1
Floor	739	–0.24	0.93	–1	1
Cleanliness of water containers					
Water, covered	753	0.12	0.99	–1	1
Container, outside	756	–0.20	0.71	–1	1
Container, inside	758	0.41	0.68	–1	1
Cleanliness related to animals					
Animal feces	760	0.70	0.71	–1	1
Animals near cooking area	760	0.38	0.92	–1	1
Cleanliness of the latrine					
Latrine	696	0.00	0.73	–1	1
Child's health					
Eye discharge	761	0.82	0.57	–1	1
Nose discharge	759	0.54	0.84	–1	1
Self-reported variables					
Handwashing self-report	760	2.69	0.89	0	4
Latrine cleaning self-report	727	2.81	1.36	0	4
Commitment to handwashing	761	2.13	1.12	0	4
Commitment to cleaning the latrine	727	2.75	0.82	0	4
Observation					
Handwashing observation	233	0.09	0.22	0	1
Household wealth					
Number of assets owned	761	4.17	2.01	0	9

SD (standard deviation), Min (minimum), and Max (maximum) values are provided.

General hygiene practice model

Figure 5 shows the model (unstandardized parameter estimates and their standard deviations are shown in Table A1) that we calculated to answer the question whether general hygiene practice explains all kinds of hygiene behaviors. The fit indices suggest an adequate fit of the model. All paths are significant. Generally, the factor loadings from different hygiene clusters to the spot-check items were strong. Only the loadings on the spot-checks for water covered and animals near cooking area were slightly below .5. Thus, the hygiene spot-checks are good indicators of various hygiene clusters. The loadings from general hygiene practice to the different hygiene clusters are slightly weaker, but only the loading on cleanliness related to animals is below .5. Primary caregiver's personal hygiene is the strongest hygiene cluster explaining general hygiene practice, since it has the highest factor loading (.76). The results confirm the structure of general hygiene practice being influenced by several clusters of hygiene behaviors. When the control variable was included in the analysis, the spot-checks were to some extent associated with household wealth (Table A1). These associations were rather small; the highest factor loading from household wealth on a spot-check was .24. Including the indicator for household wealth into the model accounts for this association of household wealth with the spot-checks.

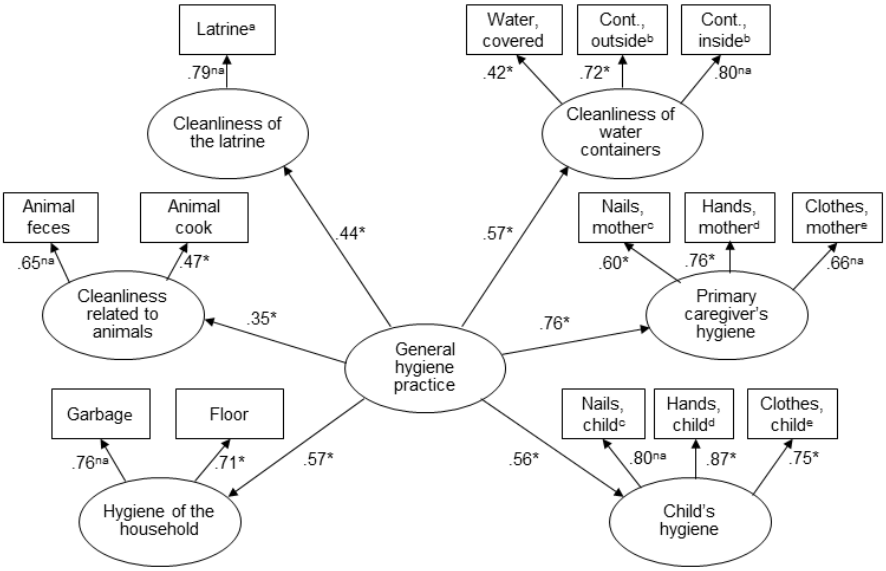

Figure 5. Standardized coefficients for the general hygiene model.

Latent constructs are shown in ovals, and observed variables are shown in rectangles. $\chi 2(68, N = 761) = 237$, $p < .001$; comparative fit index (CFI) = . 94; root mean square error of approximation (RMSEA) = .050.

The control variable household wealth is not shown; please refer to Table A1 for the respective parameter estimates.

The variance of the error of latrine was fixed at 0.1581. For the latrine measurement, a reliability of .7 was assumed. We calculated the variance error with the following equation: Variance error = (1 – reliability) * variance indicator. For latrines, this results in the following equation: Variance error = (1 – .7) * 0.527 = 0.1581.

b,c,d,e Error covariance was included. * $p < .001$.

Relationship with self-reported and observed behaviors, with commitment to hygiene and with child health

For research questions about the relationships to three other measures of hygiene, the psychological construct commitment and child's health, we extended the model and added a variable of interest and its correlation to general hygiene practice (Figure 6).

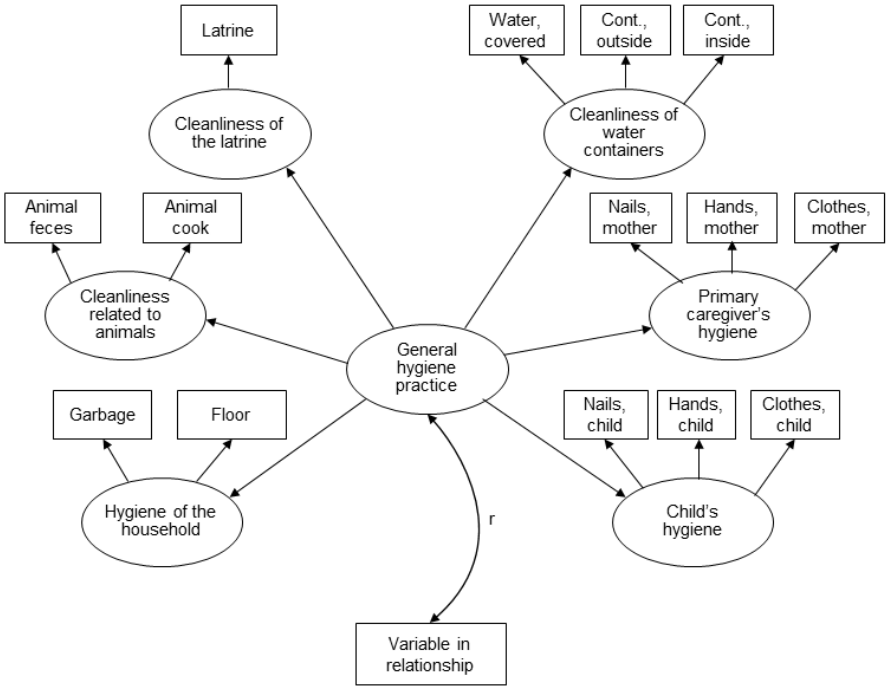

Figure 6. General hygiene model in relationship to other variables.

r = correlation.

We calculated correlations of general hygiene practice with self-reported handwashing frequency, self-reported latrine cleaning frequency, and handwashing measured by structured observation to analyze the relationship to measures other than spot-checks (Table 17; parameter estimates in Tables A2 to A4). Model fits were good. There were small to medium correlations of general hygiene practice with the three hygiene behaviors measured with self-report or structured observation. People whose general hygiene practice as estimated with spot-checks was high were more likely to report that they often their washed hands and that they often cleaned their latrine, and they were more likely to wash their hands often during the structured observation.

Table 17. Correlation of general hygiene practice with different variables.

Model	df	χ^2 (*N = 761)*	CFI	RMSEA	r[a]
General Hygiene against handwashing self-report	81	255*	.95	.046	.24*
General Hygiene against handwashing observation	81	254*	.94	.046	.31*
General Hygiene against latrine cleaning self-report	81	333*	.92	.055	.34*
General Hygiene against commitment to hygiene[b]	94	340*	.93	.051	.52*
General Hygiene against child's health[c]	94	300*	.94	.046	.46*

Note. CFI = comparative fit index; RMSEA = root mean square error of approximation.

[a] correlation of the variable in relationship with general hygiene practice. [b] latent variable calculated from the items 'commitment to handwashing' (factor loading = .42) and 'commitment to cleaning the latrine' (factor loading = .46). [c] latent variable calculated from the items 'nose discharge (factor loading = .61) and 'eyes discharge (factor loading = .54).

* $p < .001$.

In another model, we calculated the correlation to the psychological variable commitment to hygiene (Table 17, parameter estimates in Table A5). The model fits were good. The correlation of general hygiene practice with commitment to hygiene was high. People who were highly committed to hygiene behaviors were thus more likely to have high general hygiene practice.

In the last model, we calculated the correlation between general hygiene practice and child health (Table 17, parameter estimates in Table A6). The correlation of general hygiene practice to child health was medium. Children in a household with high general hygiene practice were less likely to have nose or eye discharge.

Discussion

We calculated and described a model with general hygiene practice as a latent construct that influences hygiene behaviors in six domains. We found evidence for general hygiene practice steering all kinds of hygiene behaviors. The model shows that different hygiene behaviors are not independent but related. This is in line with the study by Bartlett et al. (1992), who showed strong correlations between hygiene spot-checks. Further, the clusters of hygiene domains that we assumed were confirmed. The 14 spot-checks can be clustered into the domains of primary caregiver's hygiene, child's hygiene, household cleanliness, cleanliness related to animals, cleanliness of water containers, and cleanliness of the latrine. Other authors have proposed clustering hygiene behaviors into thematic domains (Biran et al., 2008; Boot & Cairncross, 1993; Webb et al., 2006). The novel contribution of this paper is that these theoretically assumed hygiene domains were shown to exist statistically, since hygiene behaviors in the relative domains are closely related. The primary caregiver's hygiene domain had the highest loading from general hygiene practice and is therefore the strongest single measurement of general hygiene practice. The primary caregiver has the most control over personal hygiene, and compared to the other hygiene domains, fewer disturbances occur; although traditionally in Burundi the primary caregiver is responsible for all household hygiene matters, in the other domains the other members of the household can interfere. By far the weakest indicator was cleanliness related to animals. A major problem with this indicator was that households that did not own animals were automatically rated *good*, since there were no animal feces and no animals near the cooking area.

We also looked at the relationship of general hygiene practice with self-reported measures and structured observation. Self-reports of behavior were much higher than the same behaviors as measured in the structured observation or by the spot-checks. It is likely that social desirability distorted the responses, which is a common problem with self-reports (Halder et al., 2010). Nonetheless, we found a medium correlation of general hygiene practice measured by spot-checks with self-reports. General hygiene practice was also correlated to handwashing measured during the structured observation. The literature on the associations of spot-checks with structured observations is mixed. Biran et al. (2009), who conducted spot-checks on availability of water and soap at different places, and Halder et al. (2010), who conducted spot-checks on hand cleanliness, found only very weak or no associations between their spot-checks and handwashing in structured observation. In contrast, Biran, Tabyshalieva, and Salmorbekova (2005) found a strong association between spot-checks on the availability of a

washstand with handwashing in structured observation. However, these results are not directly comparable, since we did not examine the correlation of the structured handwashing observation with a single spot-check but with general hygiene practice measured with all spot-checks.

The correlation of general hygiene practice with commitment to hygiene was high. People who said they were strongly committed to hygiene behaviors actually were more likely to have high general hygiene practice. The important role of commitment to behavior has been shown by other researchers (Lokhorst et al., 2013). Our finding provides additional evidence of the importance of the psychological construct commitment. To our knowledge, this is the first study showing an association of commitment with hygiene behavior measured with spot-checks rather than self-report. Moreover, the fact that commitment is related to general hygiene practice indicates that general hygiene practice is a coherent behavior.

General hygiene practice was also related to our measure of child health. Children were more likely to be rated healthy if they lived in a household with high general hygiene practice. This finding agrees with studies showing that hygiene measured with spot-checks was associated with child diarrhea morbidity (Kaltenthaler & Drašar, 1996; A. L. Webb et al., 2006). However, it should be noted that our measure of child health using eyes and nose discharge as indicators is very general and unspecific to diarrhea. More research is needed study the link of general hygiene practice to diarrhea specifically. In sum, general hygiene practice was related to several outcomes: measures of hygiene behaviors, the psychological construct commitment, and child health. These correlations validate the model. The correlation with the structured handwashing observation, which is often said to be the gold standard for measuring handwashing behavior gives especially strong evidence for external validity. It shows that general hygiene practice is an important and meaningful construct.

Limitations

Several limitations of the study are worth noting. The first refers to the nature of structural equation modeling. The model fit indices tell us only that the model we calculated has a good fit, and therefore, the model can serve as a good representation of the data. However, that does not mean that it is the best possible model. Other models with different structures could have the same or even better fit. Another drawback is that we measured the spot-checks only once. Ruel and Arimond (2002) recommend repeated measurements to take account of day-to-day variations in hygiene behaviors. However, there is evidence that composite indices are more

stable than single spot-checks (Webb et al., 2006) and that therefore general hygiene practice that relies on 14 measures is more or less stable. Furthermore, it is unclear how reactive spot-checks are longitudinally. Whereas Gorter et al. (1998) generally found good indicators of repeatability (kappa over .4) Arnold et al. (2015) found that spot-checks were reactive in a longitudinal study. This raises the issue of courtesy bias too. Spot-checks are considered not to be reactive if they are unannounced (Ruel & Arimond, 2002). Nevertheless, as word can spread quickly in a village, participants could have known that they were going to be visited, and we cannot exclude the possibility that courtesy bias occurred in our study. However, as our interviewers mostly encountered households with very poor hygiene, courtesy bias was rarely an issue. So far, we have only looked at the relationship of general hygiene practice to commitment. To establish the relationship of general hygiene practice with other psychosocial determinants, it will be necessary to examine more of them.

Implications for practice and conclusion

Measuring hygiene behaviors is essential for practitioners. This research provides evidence that spot-checks are a valid tool for measuring general hygiene practice. With a composite score index, the general hygiene practice of a household can be rated quickly and easily. Since spot-checks can be used with very little effort and few resources, they can be applied to much larger samples than structured observations. We showed that different hygiene behaviors are not independent and that general hygiene practice influences various hygiene behaviors. General hygiene practice was also associated with our measure of child health. The relationship to the psychological variable commitment indicates that general hygiene practice is a coherent behavior, and it gives hope for the possibility of influencing it with behavior change methods. For the future, it will be important to investigate how general hygiene practice is formed and especially whether it can be tackled with interventions. Targeting the general hygiene practice of a household directly with a single intervention and thus improving various hygiene behaviors instead of targeting each behavior individually would clearly be advantageous.

Chapter V

General discussion

1. Overview

A better understanding of what influences latrine cleanliness and habitual latrine cleaning is essential for the planning of interventions. This dissertation's purpose was to analyze how psychosocial factors, contextual factors and general hygiene determine latrine cleanliness. To achieve this, two frameworks were developed that conceptualize behavior change and latrine cleanliness. The first framework focusses on the psychosocial and contextual factors that influence habitual latrine cleaning and latrine cleanliness, and on behavior change techniques for interventions (Figure 2). The second is an extension of the specific framework for latrine cleanliness; it proposes the concept of general hygiene, of which latrine cleanliness is one of several domains (Figure 3). It also includes the influence of psychosocial and contextual factors and behavior change techniques. Additionally, it proposes general hygiene attitude as a psychological construct that influences general hygiene. Study 1 and Study 2 were based on the specific framework for latrine cleanliness and Study 3 on the general hygiene framework.

Study 1 was a correlational study showing that most of the study population in rural Burundi owned and used latrines but that the quality of their construction was very low. As hypothesized by the framework, habitual latrine cleaning strongly influenced latrine cleanliness. The strong associations of psychosocial factors with habitual latrine cleaning were also predicted within the framework. Commitment strength, perceived self-efficacy, and satisfaction with latrine cleanliness were the most important psychosocial factors. Of the contextual factors studied, only factors from the physical context regarding quality of latrine construction were associated with latrine cleanliness. Neither factors from the social context, such as income proxies or number of latrine users, nor factors from the personal context, such as education, were associated with latrine cleanliness.

Study 2 was a longitudinal study testing the effects of an intervention based on the results of Study 1. Even though the intervention positively affected habitual latrine cleaning and latrine cleanliness, the part of the framework where the behavior change techniques applied through an intervention influence psychosocial factors could not be confirmed. The intervention had very little effect on psychosocial factors. Further analysis focused on changes over time irrespective of the intervention and matched the framework quite well. Changes in psychosocial factors explained much of the changes in habitual latrine cleaning, most importantly forgetting, personal norm, commitment strength, and satisfaction with latrine cleanliness. Further, changes in habitual latrine cleaning caused changes in latrine cleanliness. Of the contextual factors, only

changes in quality of latrine construction were analyzed, as these were the only contextual factors in which changes had occurred. Again, as predicted by the framework, changes in the physical context caused a change in latrine cleanliness.

Study 3 was a correlation study based on the second framework, which introduced general hygiene. However, it was not designed to test the complete framework. Its focus was on general hygiene practice and used the outcomes of behaviors measured by spot-checks. The spot-checks observe proxies for behaviors in several domains that together constitute general hygiene practice. This aspect of the framework could be confirmed by structural equation modelling. Further results support some of the remaining elements of the framework. Though the influence of general hygiene behavior on general hygiene practice could not be tested, the hygiene behavior handwashing was related to general hygiene practice. Among psychosocial factors, the results showed that commitment strength was associated with general hygiene practice. The influence of contextual factors was not tested for. Only socio-economic status was included as control variable and was to some extent related to many of the behavioral outcomes.

The detailed results of the studies have already been discussed in previous chapters. In the remainder of this general discussion they will embedded within the proposed frameworks and a general conclusion and implications for practice will be drawn. Research gaps will be indicated throughout the discussion.

2. Appraisal of the framework to explain habitual latrine cleaning and latrine cleanliness

In this dissertation, I introduced a framework that conceptualizes latrine cleanliness and habitual latrine cleaning within the RANAS Model (Mosler, 2012; Mosler & Contzen, 2016). Figure 7 depicts in red which aspects of the framework were studied. Apart from the contextual factors, most aspects of the framework were studied at some point within this dissertation. The results of Study 1 and Study 2 could not confirm that behavior change techniques influence psychosocial factors, but they were in line with the framework regarding the influence of psychosocial factors on habitual latrine cleaning and the latter's influence on latrine cleanliness. Further, some contextual factors influenced latrine cleanliness. The specific research questions regarding the framework are discussed in more detail below. This discussion follows the sequence of the framework, which is not the same order in which the research questions were presented in previous chapters.

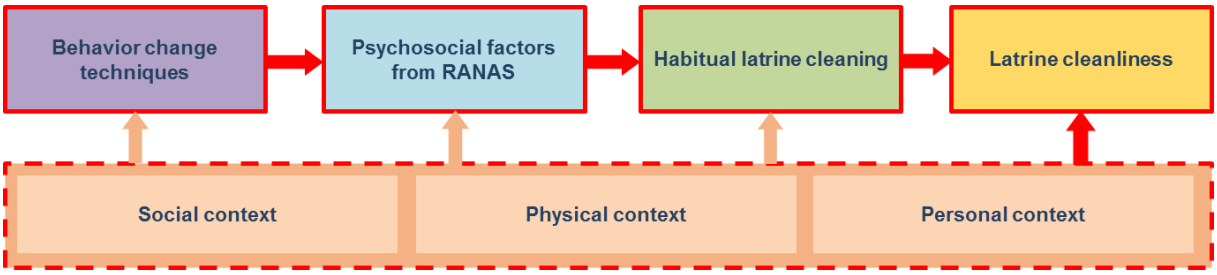

Figure 7. Aspects of the framework explaining habitual latrine cleaning and latrine cleanliness studied in this dissertation

Note. Red signifies that an aspect was studied, not that it was verified. The dotted line signifies that an aspect was only studied in part.

2.1 Influence of behavior change techniques on psychosocial factors

The framework states that behavior change techniques can be used to change specific psychosocial factors. The behavior change techniques applied in this dissertation could not be shown to do so.

Results from Study 1 indicated that an intervention should be focused on commitment strength, self-efficacy, and satisfaction with latrine cleanliness to increase habitual latrine cleaning. Together with the local partner, we decided to focus on commitment strength and satisfaction with cleanliness and developed an intervention involving several behavior change techniques. A discussion was initiated to promote a clean latrine as something desirable which leads to

satisfaction. Further, participants were prompted to commit themselves to cleaning the latrine regularly to strengthen commitment.

Study 2 evaluated the effect of the intervention and compared it to a control group. The research question that asked about the effects of the intervention on psychosocial factors (Research Question 2.4), corresponds to the part of the framework in which behavior change techniques influence specific psychosocial factors. Contrary to expectations, the intervention influenced neither satisfaction with cleanliness nor commitment strength. Weak effects were found on two other psychological factors. Although they could be explained retrospectively, they were not the intended effects. Furthermore, the study evaluated the direct effects of the intervention on habitual latrine cleaning and latrine cleanliness (Research Question 2.1) and questioned if there was an effect of the intervention on habitual latrine cleaning that was mediated by psychosocial factors (Research Question 2.6). The intervention had a positive, though not strong, effect on habitual latrine cleaning and latrine cleanliness. The mediation revealed that the intervention effect on habitual latrine cleaning was mediated by satisfaction with cleanliness, but only for a very small part. Even though this is congruent with the framework, as satisfaction was one of the factors tackled, this result cannot be given much weight. The mediation effect was very small, and the effect of the intervention on satisfaction proved insignificant. In contrast, in Uganda the RANAS model was used for planning and implementing an intervention to increase the cleaning of shared latrines (Tumwebaze & Mosler, 2015). The authors implemented group discussions and commitment techniques, and a mediation analysis confirmed that they changed behavior over psychosocial factors such as commitment strength, cleaning ease, and injunctive norms.

One further research question related to the effects of the intervention. It asked about its effects on quality of latrine construction, which had also been an aim of the intervention (Research Question 2.2). Indeed, the intervention did lead to some improvements, namely the latrines having lids on their slab holes and the height of their superstructures.

It seems surprising that an intervention succeeded in inducing behavior change, but without changing either the psychosocial factors it tackled or other psychosocial factors. One explanation could be that this was because the effect of the intervention on habitual latrine cleaning was only of moderate size. A study on consumption of safe water by Inauen et al. (2014) tested three different interventions. All of them were successful but for only two of them could the success be explained by psychosocial factors. The intervention with the smallest effect on behavior, however, could not be explained through changes in psychosocial factors. It is

plausible that it is more difficult to detect the psychosocial change mechanisms for interventions with moderate effects, such as the one in this dissertation, than for interventions with strong effects. Furthermore, even though our intervention was designed to target specific psychosocial factors, it is possible that it was implemented in a much broader way; there is a risk that an intervention becomes psychologically quite unspecific, especially when a group discussion is included. The result that the intervention had no effects on specific psychosocial factors is also in line with a systematic review on interventions based on the health belief model. The review authors found the success of interventions to be unrelated to the constructs addressed in most cases (Jones, Smith, & Llewellyn, 2014).

In sum, even though this dissertation cannot confirm the part of the framework in which behavior change techniques tackle specific psychosocial factors, the ability of behavior change techniques to do so should not be dismissed. Previous research has shown that interventions succeeded by changing exactly the psychosocial factors they had tackled (Contzen, Meili, et al., 2015; Huber et al., 2014; Tumwebaze & Mosler, 2015). The results of this dissertation show that interventions do not always work as planned, and more research is needed to understand the mechanisms underlying interventions' success or failure.

2.2 Influence of psychosocial factors on habitual latrine cleaning

The framework that I proposed states that psychosocial factors from the RANAS model (Mosler & Contzen, 2016, Mosler, 2012) influence habitual latrine cleaning. The results of this dissertation support this claim.

Both Study 1 and Study 2 analyzed the influence of psychosocial factors on habitual latrine cleaning. Study 1 analyzed the associations cross-sectionally (Research Question 1.3) and Study 2 longitudinally by analyzing how well the changes in the psychosocial factors could explain the changes in habitual cleaning behavior (Research Question 2.5). Study 1 was able to explain almost 70% of the variance in habitual latrine cleaning, and Study 2 could still explain over 40% of the variance in change of habitual latrine cleaning. The psychosocial factors that were most influential in the two studies were similar. Both found that satisfaction with cleanliness, commitment strength, personal norm, and liking to clean were important. Forgetting was only an important predictor in Study 2; however, it had not been considered as a possible predictor in Study 1. Self-efficacy was relevant only in Study 1. Some of these psychosocial factors have also been found to be relevant for cleaning in other studies. For example, commitment strength, cleaning ease or liking to clean, forgetting and the belief in the

ability to keep the latrine clean, which is similar to self-efficacy, were important predictors of cleaning of shared latrines (Tumwebaze & Mosler, 2014, 2015). Qualitative research further indicated the importance of self-efficacy, as the difficulty of cleaning was mentioned very often in focus group discussions (Kwiringira et al., 2016).

In the introduction, I elaborated how privacy, comfort, and status are main drivers for building latrines. No research has yet been conducted about their importance for latrine cleaning. Further, this dissertation did not explicitly look at those factors, but some questions related to them were still included. Two questions related to comfort. Surprisingly, even though most people clearly liked using clean latrines and felt very disgusted when using dirty latrines, this did not influence habitual latrine cleaning. There were no questions regarding status as such, but the injunctive norm is to some extent related to status. Most people thought that others approved if they had a clean latrine, but again, this did not influence habitual cleaning behavior. No questions related to privacy were included. Further work is required to investigate the role of privacy, comfort, and status for latrine cleaning more thoroughly.

As the framework predicted, the results of both studies showed that habitual cleaning behavior was highly influenced by psychosocial factors.

2.3 Influence of habitual latrine cleaning on latrine cleanliness

While the RANAS model stops with behavior, the proposed framework goes one step further and looks at the outcome of the behavior, in this case latrine cleanliness, separately. It proposes that habitual latrine cleaning influences but does not solely determine latrine cleanliness.

Both studies analyzed this aspect of the framework (Research Question 1.2; Research Question 2.3). A regression analysis conducted in Study 1 showed that habitual latrine cleaning was the strongest predictor of latrine cleanliness. It was also stronger than any of the contextual factors which were included in the analysis. Study 2 showed that if households improved in habitual latrine cleaning, the odds of their latrines improving in cleanliness were 3.5 times higher than if they did not.

The results of both studies show that habitual latrine cleaning is an important predictor of latrine cleanliness. To my knowledge, no other studies have so far examined the association between self-reported latrine cleaning and latrine cleanliness. Studies looking at the relation between other hygiene behaviors and their outcomes are also rare, and their results are mixed. No relationship was found between self-reported handwashing frequency and bacterial

contamination of hands, but the self-reported time passed since the last handwashing was associated with bacterial contamination (Pickering et al., 2010). Further, the self-reported use of a beverage storing vessel led to lower bacterial contamination of beverages (Sobel et al., 1998).

Apart from being a framework specifically for the case of habitual latrine cleaning and latrine cleanliness, the framework's novel contribution is its analysis of the outcome of behavior separately from the behavior itself. It demonstrated that self-reported habitual latrine cleaning actually influences latrine cleanliness. This is important, as self-reported behavior has often been criticized as unreliable (Manun'Ebo et al., 1997; Ram, 2013).

2.4 Influence of contextual factors

The framework suggests that factors from the social, physical, and personal contexts influence behavior change techniques, psychosocial factors, habitual latrine cleaning, and latrine cleanliness. This dissertation focused on their influence on latrine cleanliness. Factors from the physical context, namely the quality of latrine construction, influenced latrine cleanliness, whereas factors from the social and personal contexts were generally irrelevant. As indicated by the dotted line in Figure 7, the contextual factors were not studied comprehensively, and factors from the social context were only included in part.

Study 1 reports on sanitation in general in the rural Burundian population it studied (Research Question 1.1) and finds an association of contextual factors with latrine cleanliness (Research Question 1.2). We found that the majority of people owned private latrines, although some shared it with their immediately neighboring households. However, most latrines were in bad shape regarding the quality of their construction. They often lacked doors, the slabs were mostly constructed of wooden sticks covered with soil and were thus uneven and holed, and very few latrines had a lid on the slab hole. In addition, most latrines were rated as only moderately clean.

So far, most research has focused only on the associations of latrine cleanliness with the quality of latrine construction, factors from the physical context (e.g. Diallo et al., 2007; Nakagiri et al., 2015; Irish, Aiemjoy, Torondel, Abdelahi, & Ensink, 2013). Study 1 analyzed factors from the social, physical, and personal contexts. A factor in the social context, whether a latrine was private or shared, had no influence on its cleanliness. This contrasts with the commonly held view that shared latrines cannot be considered as basic or improved sanitation (JMP, 2015) because they are generally believed to be at high risk of being unclean. On the other hand, most latrines were shared by only two households; one other study has even proposed that sharing

by up to four households should be considered safe (Günther et al., 2012). Among the personal context factors, we analyzed the relevance of household size, education, and income. Only income was to some extent related to latrine cleanliness. In contradiction to Tumwine et al., (2003) education was not associated with latrine cleanliness. This is also surprising, as it is one of the most important contextual factors associated with access to sanitation (e.g., Rodgers et al., 2007; Okurut & Charles, 2014). Among physical context factors, several of the characteristics of quality of latrine construction were related to cleanliness. Latrines were cleaner if they had a door, if their superstructure was high and built of solid material, and if the slab was of good quality. The study further analyzed the influence of some of the contextual factors, namely education and income, on habitual latrine cleaning. This did not address any of the study's research questions, but they were included in the regression model as control variables. Similar to the results regarding their influence on latrine cleanliness, education was not relevant and income only to some extent.

Study 2 followed up the results of the first study and looked at the influence of changes in the quality of latrine construction on latrine cleanliness. To my knowledge, this is the first longitudinal study on this subject. The results confirmed the results of Study 1, as installing doors and improving the superstructures led to cleaner latrines, as did putting lid on the slab holes. However, improving the slabs did not lead to cleaner latrines. Even though the results of the two studies did not exactly agree about which characteristics are important, they show that the quality of latrine construction in general influences its cleanliness. This is in line with previous research (e.g. Diallo et al., 2007, Nakagiri et al., 2015, Irish, Aiemjoy, Torondel, Abdelahi, & Ensink, 2013). There are two plausible explanations for why increasing the quality of latrine construction leads to better cleanliness: Latrines of better quality may be easier to clean, and users might value them more and thus use them more carefully. This is an important finding as it shows how improving latrines can enhance their cleanliness. By analyzing the influence of contextual factors on latrine cleanliness and comparing it to the influence of habitual latrine cleaning, we saw that both influence latrine cleanliness but that the influence of habitual latrine cleaning was stronger. Comparing the influence of behavior and context on the desired outcome helps to decide whether it makes sense to plan a pure behavior change intervention or whether infrastructure should be improved as well.

The two studies showed that contextual factors influenced latrine cleanliness. The framework suggests that contextual factors also influence behavior, psychosocial factors, and behavior change techniques. However, these were not analyzed, so further research is needed to examine

the influence of contextual factors on habitual latrine cleaning, psychosocial factors, and behavior change techniques. Even though the two studies analyzed factors from all three contexts (social, physical, and personal), the influence of the physical context was most closely studied, and many factors from the social context were not considered. For example, it remains unclear how law and policies or culture may influence habitual latrine cleaning and latrine cleanliness.

3. Appraisal of the general hygiene framework

In the introduction, I proposed a second framework that depicts habitual latrine cleaning and latrine cleanliness within the concept of general hygiene. Figure 8 depicts in red which aspects of this framework were studied. Noticeably, the second framework was not evaluated as a whole, but a strong focus was laid on the concept of general hygiene practice. The results of Study 3 confirmed its structure using spot-checks. No analyses were conducted regarding behavior change techniques. Among psychosocial factors, we found that commitment strength was associated with general hygiene practice. The concept of general hygiene behavior was not studied as such, but two hygiene behaviors, latrine cleaning and handwashing, were related to general hygiene practice. Of the contextual factors, only socio-economic status was included in the analysis; it was associated with most other variables. The contributions of Study 3 to the framework are here discussed in more detail.

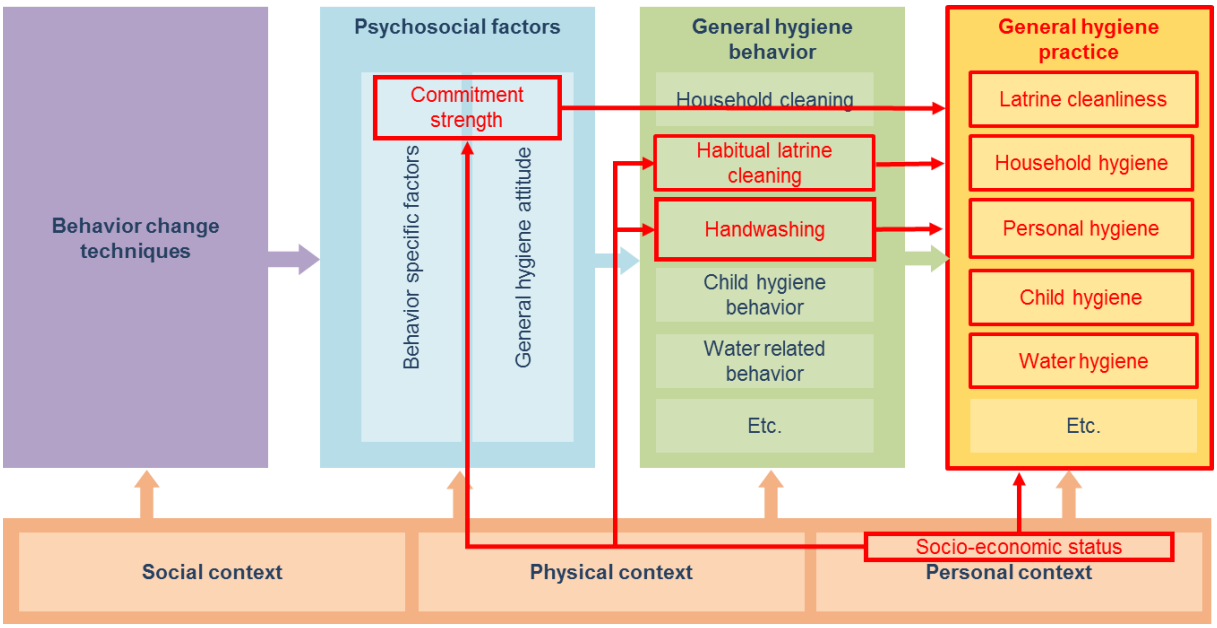

Figure 8. Aspects of the general hygiene framework studied in this dissertation

Note: Red signifies that an aspect was studied, not that is was verified.

3.1 General hygiene practice

The second framework proposes that the outcomes of hygiene behaviors can be aggregated to general hygiene practice. It assumes that more similar practices are related more closely and thus proposes various domains that together form general hygiene practice. Study 3 investigated and confirmed that structure (Research Question 3.1).

A structural equation model based on spot-checks showed that general hygiene practice can be characterized as constituted by several domains. The domains we proposed and found were latrine cleanliness, household hygiene, personal hygiene, child hygiene, and water hygiene. The framework proposes these domains but leaves space for the inclusion of additional domains. Indeed, it might well make sense to include food-related hygiene, e.g. how food is stored, as domain into the model (cf. Boot & Cairncross, 1993). The clustering of spot-checks into domains has already been proposed by Webb et al. (2006). However, they simply built separate indices for the domains without providing statistical evidence for their clusters. The model fit indices show that we can confirm that the conceptual structure of general hygiene practice is composed of different domains. Overall, the indices of the fit to the model were good. They indicate how well a model fits the data it is based on. A good fit means that the model is a good representation of the data. It is thus reasonable to characterize general hygiene practice as having the conceptual structure hypothesized by the framework. However, the fit indices do not tell us whether a model is the only or best solution. It could be that other conceptual structures of general hygiene have equal or better fits. Future studies to compare a range of possible conceptions of general hygiene practice are therefore recommended. Even though other conceptual structures of general hygiene practice are conceivable, the data show that the spot-checks correlate strongly and that the assumption of general hygiene practice is plausible.

The study also showed that general hygiene practice was related to a measure for child health (Research Question 3.4). Whilst the link to health is quite clear for a few of the behavioral outcomes of general hygiene practice (e.g. Ejemot-Nwadiaro, Ehiri, Meremikwu, & Critchley, [2008] for the effect of handwashing on diarrhea; Wolf et al., [2014] for the effect of clean water on diarrhea), for most others, such as cleanliness of clothes or presence of garbage, the link is still under-researched. This study indicates their relevance for health on an aggregate level, but further research is needed to establish that finding, especially as our measure of health was quite unspecific.

The results showed that spot-checks are useful for rating the overall hygiene practice of a household. Even though it is suggested that spot-checks be made several times because of day-to-day variations (Ruel & Arimond, 2002), composite indices based on single measurements of spot-checks are believed to be stable (Webb et al., 2006). It can be very convenient to use spot-checks for a quick rating of the general hygiene practice of households because they are less time-consuming and less difficult to conduct than other measures such as structured observation or questionnaires. This quick rating method could be applied without much training of data

collectors and could help practitioners identify households most in need of hygiene interventions.

In brief, the conceptual structure of general hygiene practice proposed by the framework could be confirmed. Further, the utility of spot-checks for measuring general hygiene practice was demonstrated.

3.2 General hygiene behavior

The general hygiene framework presumes that general hygiene behavior influences general hygiene practice. The conceptual structure of general hygiene behavior is reflected by the structure of general hygiene practice and is based on a variety of hygiene behaviors. More similar behaviors, such as washing hands and cleaning fingernails, cluster in specific behavioral domains. The behavioral domains together form general hygiene behavior.

Although Study 3 did not examine the conceptual structure of general hygiene behavior directly, it found that conceptual structure based on spot-checks. As the outcomes of behavior, spot-checks mirror behavior and are often also used as direct proxies for behavior (Webb et al., 2006). In this sense, the structural equation model of general hygiene practice also indicates that general hygiene behavior has the conceptual structure proposed by the model. Research using questionnaires on hygiene behavior has found very similar conceptual structures (Ipek Coban & Bilgin, 2015; Stevenson et al., 2009).

As Study 3 did not directly model general hygiene behavior, its influence on general hygiene practice could also not be assessed. However, we analyzed the relationships of some hygiene behaviors with general hygiene practice (Research Question 3.2). Moderate correlations were found with self-reported handwashing, self-reported latrine cleaning, and observed handwashing. Due to the correlational nature of the study, it is impossible to determine the direction of influence. The fact that the correlations were only moderate is not surprising, as general hygiene practice is an aggregate of many spot-checks, whereas the behaviors were based on specific hygiene behaviors. Future work should be undertaken to determine whether the associations would be stronger if general hygiene practice and a similar aggregate of hygiene behaviors were correlated.

In summary, the results are an indication of the conceptual structure of general hygiene behavior and of the assumption that general hygiene behavior influences general hygiene practice, but more research is needed to confirm this.

3.3 General hygiene attitude

Within the general hygiene framework, general hygiene attitude and behavior-specific psychosocial factors are together assumed to be responsible for general hygiene behavior. Unfortunately, this dissertation could not study this assumption in detail. Still, the results of Study 3 provide some indications. First, commitment strength towards hygiene behaviors was associated with general hygiene practice. Second, the mere existence of general hygiene practice, confirmed by the strong correlations between hygiene practices, suggest that they are steered by an underlying mindset, which I here term general hygiene attitude.

Study 3 asked whether commitment towards hygiene behaviors, a psychosocial factor, was related to general hygiene practice (Research Question 3.3) and indeed found a medium correlation. This shows that a psychosocial factor is important for general hygiene practice. However, it is unclear whether the measure of commitment towards hygiene behaviors that we used should be considered part of general hygiene attitude. In the framework, I proposed general hygiene attitude in addition to behavior-specific psychosocial factors. The measure we used is an aggregated measure of commitment strength towards several hygiene behaviors, but it is based on two behavior-specific questions. In the future, it would be interesting to use measures of general hygiene attitude which are not based on behavior-specific questions but on questions regarding hygiene generally. These could be questions such as ‘how important is hygiene to you in general?’ or ‘how much do you enjoy it if your surroundings are clean?’ At this point, it is also worth mentioning the principle of compatibility (Ajzen & Fishbein, 2005). This principle requires that measures of attitude and behavior involve exactly the same action, target, context, and time elements. For most studies, this means that attitudes should not be measured generally but towards the specific behavior to be predicted. In the case of general hygiene behavior, the opposite would be true. Attitudes and other psychosocial factors, should be measured in a more general way to be predictive of general hygiene behavior. For example, Weigel and Newman (1976) found that general attitude towards ecologically oriented behaviors was only weakly related to single ecologically oriented behaviors but related strongly to a comprehensive behavioral index.

The finding of the structure of general hygiene practice suggests that there is a mindset, presumably general hygiene attitude, which influences it. If outcomes of all kinds of behavior are correlated, there is most probably something which steers this correlation. I presume that they are all influenced by the same psychosocial construct, general hygiene attitude. However, to develop a full picture of general hygiene attitude, additional studies will be needed to exclude

the possibility that the correlation between different hygiene behaviors is caused by a third variable.

3.4 Contextual factors in the general hygiene framework

The general hygiene framework presumes that contextual factors influence the whole behavior change process by influencing behavior change techniques, general hygiene attitude and behavior-specific psychosocial factors, general hygiene behavior, and general hygiene practice. However, Study 3 offers very little insight towards their role. Small correlations were found between household wealth and most variables included in the model, but otherwise no other contextual factors were analyzed.

Study 3 included no specific research question regarding contextual factors. We included household wealth as control variable, but that was the only contextual factor. We added it to every model and calculated its correlation to each variable. In general, we found small but significant correlations with spot-checks, behaviors, and commitment strength. This is in line with other findings that income or household wealth influence hygiene behaviors (e.g. Okurut & Charles, 2014; Unicef and World Health Organization, 2015). No statements can be made about causalities, but the correlations indicate that general hygiene practice, general hygiene behavior and commitment strength are associated with household wealth to some extent. As mentioned in the detailed discussion of the study in Chapter 4, it should be noted that this does not mean that general hygiene practice is biased by household wealth. By adding household wealth to the models, its influence is controlled for, and the correlations between the different spot-checks in the models are independent of household wealth.

Study 3 could make no statements regarding the influence of most contextual factors. However, it is likely that general hygiene attitude and behavior-specific psychosocial factors, general hygiene behavior, and general hygiene practice are all influenced by household wealth to a small extent.

3.5 Overall appraisal of the general hygiene framework

In this last subsection appraising the general hygiene framework, I would like to elaborate on the merits of the framework both for the specific case of latrine cleanliness and in general.

Several studies indicate that hygiene behaviors are related and form different domains and overall general hygiene (Ipek Coban & Bilgin, 2015; Stevenson et al., 2009). However, Study 3 is the first to the best of my knowledge to demonstrate this conceptual structure on the basis

of spot-checks rather than self-reports. This makes a strong case for the existence of general hygiene practice and general hygiene behavior, as problems of social desirability bias or wrong memory recall can be excluded. For the specific case of latrine cleanliness and habitual latrine cleaning, this means that they should not be looked at individually but within the broader perspective of all kinds of hygiene behaviors. If other hygiene behaviors are low for any reason, it is unlikely that habitual latrine cleaning will be high, as the different hygiene behaviors are not independent; they influence each other. What are included in the framework but were not examined by Study 3 are interventions and behavior change techniques. Such intervention studies should be conducted. An intervention directly targeting general hygiene attitude and therefore general hygiene behavior could then be evaluated. It would also be interesting to investigate what happens to general hygiene behavior after an intervention targeting a specific behavior. Will only that specific behavior change, or will it cause general hygiene behavior to change?

Further, it is worth mentioning that the general hygiene framework opens a new perspective. Habitual latrine cleaning and other hygiene behaviors are not viewed merely as health behaviors but also as hygiene behaviors. Health behaviors and hygiene behaviors partly overlap but also differ in many cases. Whereas latrine cleaning or handwashing can be both, using a deodorant is certainly only a hygiene behavior, and regular participation in sport is not. The perspective of hygiene may lead to different entry points for interventions. Considering motivators for hygiene rather than health may lead to quite different results. In future investigations, it might be possible to determine the extent to which the motivators and psychosocial factors that lead to hygiene behavior differ from those leading to health behavior.

4. Limitations

I here elaborate on the shortcomings of the design, sample, and measures and propose solutions for future research.

4.1 Study design

Study 1 and Study 3 were cross-sectional studies, and therefore no conclusions can be drawn on causalities. Still, for Study 1 there was a longitudinal follow-up with Study 2 that confirmed the importance of many of the psychosocial and contextual factors for habitual latrine cleaning and latrine cleanliness identified in Study 1, for example commitment strength and quality of latrine construction. However, no follow-up exists for Study 3, so the influence of various hygiene behaviors and commitment strength on general hygiene practice still needs to be confirmed by future longitudinal studies.

The evaluation of the intervention conducted in Study 2 would best have been performed with a randomized control trial. We only applied a non-randomized controlled trial design in which the intervention and control conditions were assigned to two clusters each. The problem is that the clusters, two different villages, can have different attributes that influence the success of the intervention. If we had randomly assigned households within the villages to the intervention or control groups, we could have controlled for this. However, this was not possible because we had to ensure that the control group would not have any contact with the intervention. Another option would have been to assign at least five clusters to each condition and then include the clusters as levels in the analyses (Campbell, Piaggio, Elbourne, & Altman, 2012). However, this was not possible, as we only had the resources to conduct this study in six villages. Indeed, it was the case that the intervention and control groups differed in some characteristics. The control group had higher socio-economic status and higher values in habitual latrine cleaning and latrine cleanliness at baseline. By conducting longitudinal studies and analyzing differences within participating households and not absolute values we took this into account to some extent. Nevertheless, it is possible that these differences affected the intervention.

Another drawback of Study 2 is the long time-lag between the baseline and the intervention. The intervention was carried out almost two years after the baseline. We cannot rule out the chance that changes were caused by confounding variables, such as time, rather than the intervention. On the other hand, for the analyses we conducted irrespective of the intervention,

the long time-lag between baseline and follow-up is also an asset that makes those results more robust.

In Study 1 and Study 3, the samples of over 700 households were quite large. This can lead to negligible effects reaching significance. However, we calculated effect sizes whenever feasible to help interpret the relevance of effects. In Study 2, samples were smaller, with almost 200 households for the intervention group and about 90 for the control group. Although both samples can be regarded as adequate, their differing sizes can pose a problem. The same effect might reach significance in the intervention group but not in the control group. Still, this was not a problem regarding the main effect of the intervention on habitual latrine cleaning and on latrine cleanliness, as here the control group even decreased in its means.

4.2 Data measures

The items we used for measuring the psychosocial variables have been used by several studies in similar questionnaires before (e.g. Huber, Tobias & Mosler, 2014; Inauen & Mosler, 2014; Tumwebaza & Mosler, 2014). However, this is the first time they were used in the Burundian local language Kirundi, and we did not validate and test them for reliability. To ensure correct translation, we translated and then retranslated the questionnaire. During the interviewer training, each item was re-checked for correct translation and its applicability tested during a short pilot test.

The spot-checks we used to measure behavioral outcomes were not evaluated for reliability either. We did not test inter-rater reliability but took several measures to encourage consistent ratings within the interviewer team. First, we gave clear instructions about the ratings during training and second, interviewers had to train in teams of two and independently assess spot-checks and then compare them. Furthermore, teams were switched constantly during the pilot phase. We did not conduct any analysis of retest reliability. One study has found that the retest reliability of single spot-checks was rather low due to high day-to-day variations, but the same study's retest reliability of aggregate measures was high (Ruel & Arimond, 2002). Applied to our Study 3, this would mean that although the measurement of the single spot-checks might not be very reliable, the measurement of the general hygiene practice should be. For Study 1 and Study 2, however, this also means that the assessment of latrine cleanliness by spot-checks could be improved. Future research on latrine cleanliness should measure latrine cleanliness several times, preferably on different days and on different times of the day.

5. Conclusion and practical implications

The sustainable development goals set an ambitious agenda for the world. One of these goals is to achieve access to sanitation for all. Besides access, however, it is also crucial that facilities are hygienic and clean to achieve health and well-being. Moreover, users might return to open defecation if facilities are unclean. The aim of this dissertation was to contribute to a better understanding of the influences on latrine cleanliness. Therefore, contextual and psychosocial factors influencing latrine cleanliness and habitual latrine cleaning were studied in rural Burundi. Moreover, the role of latrine cleanliness was analyzed in the broader perspective of general hygiene.

Based on the RANAS model of behavior change, a framework was developed and tested specifically to predict and improve habitual latrine cleaning and latrine cleanliness. An evidence-based intervention was tested targeting specific psychosocial factors. Even though the intervention was successful in improving habitual latrine cleaning and latrine cleanliness, contrary to assumptions, it had practically no effects on psychosocial factors. Nevertheless, it showed that psychosocial factors were crucial for habitual latrine cleaning. Particularly important factors were how committed people felt to cleaning, how satisfied they were with their latrines' cleanliness, and how much they liked cleaning. The novel approach of this dissertation was to go further than the prediction of behavior and specifically examine the outcome of behavior, in this case latrine cleanliness, to analyze the extent to which it is influenced by behavior and contextual factors. It was found that behavior was the most important predictor of latrine cleanliness. This means that self-reports, which are often criticized for unreliable over-reporting, are viable in this context for measuring habitual latrine cleaning. More importantly, the results showed that users themselves have control over cleanliness, which is very positive. They can actually control the cleanliness of their latrine by their own actions. Still, some contextual factors, specifically the quality of latrine construction, also influenced cleanliness.

This dissertation further analyzed latrine cleanliness as one part of general hygiene practice. A second framework was proposed, expanded to incorporate general hygiene. Behavioral outcomes measured by spot-checks indicated that diverse kinds of hygiene behaviors are closely related and together constitute general hygiene practice. Moreover, more similar behaviors are more closely related and cluster in behavioral domains. Commitment strength, several hygiene behaviors, and a measure of child health were all related to general hygiene practice.

Several practical implications of this dissertations findings regarding the improvement of latrine cleanliness are noteworthy. Behavior change interventions make sense; behavior was the most important determinant of latrine cleanliness. Still, promoting better quality of latrine construction could further enhance latrine cleanliness. Behavior change interventions should focus on psychosocial factors, as these were crucial for habitual latrine cleaning. Including the behavioral outcome, latrine cleanliness, explicitly in the analysis can also be advantageous because it is more tangible and concrete than the behavior and certainly more so than psychosocial factors. Looking at the whole framework again can help to convince skeptical practitioners or field staff of the need for behavior change interventions, because addressing abstract notions such as psychosocial factors can ultimately improve something very concrete and measurable such as latrine cleanliness.

The results for general hygiene practice imply that it could be beneficial to analyze latrine cleanliness from the perspective of general hygiene. The prevention of diseases related to low hygiene would be greatly aided by finding ways to measure general hygiene attitude and determine its influence on general hygiene behavior. This knowledge would enable the planning of interventions targeting general hygiene attitude directly and therefore many hygiene behaviors at once. If those interventions were successful with the same resources, more behaviors could be reached and the impact on health would presumably be greater.

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Appendix

Table A1. Parameter estimates for the structural equation model „General hygiene practice“

Parameter Estimate	Unstandardized	Standardized
Measurement Model Estimates		
Cleanliness of water containers → Water, covered	0.77 (0.14)	.42**
Cleanliness of water containers → Container, outside	.94 (0.08)	.72**
Cleanliness of water containers → Container, inside	1.00	.80 [na]
Primary caregiver's hygiene → Nails, mother	0.91 (0.07)	.60**
Primary caregiver's hygiene → Hands, mother	1.32 (0.09)	.76**
Primary caregiver's hygiene → Clothes, mother	1.00	.66 [na]
Child's Hygiene → Nails, child	1.00	.80 [na]
Child's Hygiene → Hands, child	1.24 (0.05)	.87**
Child's Hygiene → Clothes, child	0.94 (0.04)	.75**
Cleanliness related to animals → Animal feces	1.00	.65 [na]
Cleanliness related to animals → Animal cook	0.93 (0.27)	.47*
Cleanliness of the latrine → Latrine	1.00	.79 [na]
Hygiene of the household →Garbage	1.00	.76 [na]
Hygiene of the household → Floor	0.96 (0.10)	.71**
Structural Model		
General hygiene practice → Cleanliness of the latrine	0.25 (0.03)	.44**
General hygiene practice → Cleanliness related to animals	0.16 (0.03)	.35**
General hygiene practice → Hygiene of the household	0.39 (0.04)	.57**
General hygiene practice → Primary caregiver's hygiene	0.40 (0.03)	.76**
General hygiene practice → Cleanliness of water containers	0.31 (0.03)	.57**
General hygiene practice → Child's Hygiene	0.35 (0.03)	.56**
Control: household wealth		
Control (household wealth) → Latrine	0.10 (0.01)	.28**
Control (household wealth) → Animal cook	0.01 (0.02)	.01
Control (household wealth) → Floor	0.08 (0.02)	.18**
Control (household wealth) → Animal feces	-0.01 (0.01)	-.02
Control (household wealth) → Water, covered	0.10 (0.02)	020**
Control (household wealth) → Container, outside	0.06 (0.01)	.18**
Control (household wealth) → Container, inside	0.06 (0.01)	.19**
Control (household wealth) → Nails, mother	0.08 (0.01)	.20**
Control (household wealth) → Hands, mother	0.07 (0.02)	.16**
Control (household wealth) → Clothes, mother	0.09 (0.01)	.22**
Control (household wealth) → Nails, child	0.04 (0.01)	.10*
Control (household wealth) → Hands, child	0.06 (0.02)	.13**
Control (household wealth) → Clothes, child	0.06 (0.01)	.15**
Control (household wealth) → Garbage	0.06 (0.02)	.13*

Note: Standard errors are in parentheses; $\chi^2(68, N = 761) = 237$; $p < .001$; CFI = . 95; RMSEA = .050.

* $p < .001$, ** $p < .001$

Table A2. Parameter estimates for the structural equation model „General hygiene practice: Relationship with Handwashing self-report“

Parameter Estimate	Unstandardized	Standardized
Measurement Model Estimates		
Cleanliness of water containers → Water, covered	0.80 (0.14)	.43**
Cleanliness of water containers → Container, outside	0.95 (0.08)	.71**
Cleanliness of water containers → Container, inside	1.00	.78 [na]
Primary caregiver's hygiene → Nails, mother	0.92 (0.07)	.60**
Primary caregiver's hygiene → Hands, mother	1.34 (0.09)	.76**
Primary caregiver's hygiene → Clothes, mother	1.00	.66 [na]
Child's Hygiene → Nails, child	1.00	.80 [na]
Child's Hygiene → Hands, child	1.24 (0.05)	.87**
Child's Hygiene → Clothes, child	0.94 (0.04)	.75**
Cleanliness related to animals → Animal feces	1.00	.63
Cleanliness related to animals → Animal cook	1.00 (0.27)	.48*
Cleanliness of the latrine → Latrine	1.00	.79 [na]
Hygiene of the household → Garbage	1.00	.75 [na]
Hygiene of the household → Floor	0.97 (0.10)	.71**
Structural Model		
General hygiene practice → Cleanliness of the latrine	0.25 (0.03)	.43**
General hygiene practice → Cleanliness related to animals	0.16 (0.03)	.36**
General hygiene practice → Hygiene of the household	0.39 (0.04)	.58**
General hygiene practice → Primary caregiver's hygiene	0.40 (0.03)	.76**
General hygiene practice → Cleanliness of water containers	0.30 (0.03)	.56**
General hygiene practice → Child's Hygiene	0.35 (0.03)	.56**
Covariance General hygiene practice and Handwashing self-report	0.21 (0.04)	.24**
Control: household wealth		
Control (household wealth) → Latrine	0.10 (0.01)	.28**
Control (household wealth) → Animal cook	0.01 (0.02)	.01
Control (household wealth) → Floor	0.08 (0.02)	.18**
Control (household wealth) → Animal feces	-0.01 (0.01)	-.02
Control (household wealth) → Water, covered	0.10 (0.02)	.20**
Control (household wealth) → Container, outside	0.06 (0.01)	.18**
Control (household wealth) →Container, inside	0.06 (0.01)	.19**
Control (household wealth) → Nails, mother	0.08 (0.01)	.20**
Control (household wealth) → Hands, mother	0.07 (0.02)	.16**
Control (household wealth) → Clothes, mother	0.09 (0.01)	.22**
Control (household wealth) → Nails, child	0.04 (0.01)	.10*
Control (household wealth) → Hands, child	0.06 (0.02)	.13**
Control (household wealth) → Clothes, child	0.06 (0.01)	.15**
Control (household wealth) → Garbage	0.06 (0.02)	.13*
Control (household wealth) → Handwashing self-report	0.11 (0.02)	.26**

Note: Standard errors are in parentheses; $\chi^2(81, N = 761) = 255$; $p < .001$; CFI = . 95; RMSEA = .046.

* $p < .01$, ** $p < .001$

Table A3. Parameter estimates for the structural equation model „General hygiene practice: Relationship with Handwashing observation“

Parameter Estimate	Unstandardized	Standardized
Measurement Model Estimates		
Cleanliness of water containers → Water, covered	0.78 (0.14)	.42**
Cleanliness of water containers → Container, outside	0.94 (0.08)	.71**
Cleanliness of water containers → Container, inside	1.00	.79 [na]
Primary caregiver's hygiene → Nails, mother	0.91 (0.07)	.61**
Primary caregiver's hygiene → Hands, mother	1.32 (0.09)	.76**
Primary caregiver's hygiene → Clothes, mother	1.00	.66 [na]
Child's Hygiene → Nails, child	1.00	.79 [na]
Child's Hygiene → Hands, child	1.24 (0.05)	.87**
Child's Hygiene → Clothes, child	0.94 (0.04)	.75**
Cleanliness related to animals → Animal feces	1.00	.65
Cleanliness related to animals → Animal cook	0.98 (0.28)	.48**
Cleanliness of the latrine → Latrine	1.00	.79 [na]
Hygiene of the household → Garbage	1.00	.76 [na]
Hygiene of the household → Floor	0.96 (0.10)	.71**
Structural Model		
General hygiene practice → Cleanliness of the latrine	0.25 (0.03)	.43**
General hygiene practice → Cleanliness related to animals	0.16 (0.03)	.34**
General hygiene practice → Hygiene of the household	0.39 (0.04)	.56**
General hygiene practice → Primary caregiver's hygiene	0.40 (0.03)	.77**
General hygiene practice → Cleanliness of water containers	0.30 (0.03)	.56**
General hygiene practice → Child's Hygiene	0.35 (0.03)	.57**
Covariance General hygiene practice and Handwashing observation	0.07 (0.02)	.31**
Control: household wealth		
Control (household wealth) → Latrine	0.10 (0.01)	.28**
Control (household wealth) → Animal cook	0.01 (0.02)	.01
Control (household wealth) → Floor	0.08 (0.02)	.18**
Control (household wealth) → Animal feces	-0.01 (0.01)	-.02
Control (household wealth) → Water, covered	0.10 (0.02)	.20**
Control (household wealth) → Container, outside	0.06 (0.01)	.18**
Control (household wealth) → Container, inside	0.06 (0.01)	.19**
Control (household wealth) → Nails, mother	0.08 (0.01)	.20**
Control (household wealth) → Hands, mother	0.07 (0.02)	.16**
Control (household wealth) → Clothes, mother	0.09 (0.01)	.22**
Control (household wealth) → Nails, child	0.04 (0.01)	.10*
Control (household wealth) → Hands, child	0.06 (0.02)	.13**
Control (household wealth) → Clothes, child	0.06 (0.01)	.15**
Control (household wealth) → Garbage	0.06 (0.02)	.13*
Control (household wealth) → Handwashing observation	0.02 (0.01)	.17**

Note: Standard errors are in parentheses; $\chi^2(81, N = 761) = 254$; $p < .001$; CFI = . 94; RMSEA = .046.

* $p < .01$, ** $p < .001$

Table A4. Parameter estimates for the structural equation model „General hygiene practice: Relationship with Latrine cleaning self-report“

Parameter Estimate	Unstandardized	Standardized
Measurement Model Estimates		
Cleanliness of water containers → Water, covered	0.76 (0.13)	.42**
Cleanliness of water containers → Container, outside	0.92 (0.08)	.71**
Cleanliness of water containers → Container, inside	1.00	.81 [na]
Primary caregiver's hygiene → Nails, mother	0.91 (0.07)	.60**
Primary caregiver's hygiene → Hands, mother	1.32 (0.09)	.76**
Primary caregiver's hygiene → Clothes, mother	1.00	.66 [na]
Child's Hygiene → Nails, child	1.00	.79 [na]
Child's Hygiene → Hands, child	1.24 (0.05)	.87**
Child's Hygiene → Clothes, child	0.94 (0.04)	.75**
Cleanliness related to animals → Animal feces	1.00	.67
Cleanliness related to animals → Animal cook	0.88 (0.25)	.45**
Cleanliness of the latrine → Latrine	1.00	.79 [na]
Hygiene of the household → Garbage	1.00	.77 [na]
Hygiene of the household → Floor	0.92 (0.10)	.70**
Structural Model		
General hygiene practice → Cleanliness of the latrine	0.30 (0.03)	.53**
General hygiene practice → Cleanliness related to animals	0.17 (0.03)	.35**
General hygiene practice → Hygiene of the household	0.39 (0.04)	.55**
General hygiene practice → Primary caregiver's hygiene	0.37 (0.03)	.70**
General hygiene practice → Cleanliness of water containers	0.34 (0.03)	.62**
General hygiene practice → Child's Hygiene	0.32 (0.03)	.51**
Covariance General hygiene practice and latrine cleaning self-report	0.11 (0.02)	.34**
Control: household wealth		
Control (household wealth) → Latrine	0.10 (0.01)	.28**
Control (household wealth) → Animal cook	0.01 (0.02)	.01
Control (household wealth) → Floor	0.08 (0.02)	.18**
Control (household wealth) → Animal feces	-0.01 (0.01)	-.02
Control (household wealth) → Water, covered	0.10 (0.02)	.20**
Control (household wealth) → Container, outside	0.06 (0.01)	.18**
Control (household wealth) → Container, inside	0.06 (0.01)	.19**
Control (household wealth) → Nails, mother	0.08 (0.01)	.20**
Control (household wealth) → Hands, mother	0.07 (0.02)	.16**
Control (household wealth) → Clothes, mother	0.09 (0.01)	.22**
Control (household wealth) → Nails, child	0.04 (0.01)	.10*
Control (household wealth) → Hands, child	0.06 (0.02)	.13**
Control (household wealth) → Clothes, child	0.06 (0.01)	.15**
Control (household wealth) → Garbage	0.06 (0.02)	.13*
Control (household wealth) → Latrine cleaning self-report	0.04 (0.01)	.24**

Note: Standard errors are in parentheses; $\chi^2(81, N = 761) = 333$; $p < .001$; CFI = . 92; RMSEA = .055.

* $p < .01$, ** $p < .001$

Table A5. Parameter estimates for the structural equation model „General hygiene practice: Relationship with Commitment“

Parameter Estimate	Unstandardized	Standardized
Measurement Model Estimates		
Cleanliness of water containers → Water, covered	0.84 (0.13)	.44**
Cleanliness of water containers → Container, outside	0.93 (0.08)	.68**
Cleanliness of water containers → Container, inside	1.00	.76 [na]
Primary caregiver's hygiene → Nails, mother	0.91 (0.07)	.60**
Primary caregiver's hygiene → Hands, mother	1.33 (0.09)	.76**
Primary caregiver's hygiene → Clothes, mother	1.00	.66 [na]
Child's Hygiene → Nails, child	1.00	.80 [na]
Child's Hygiene → Hands, child	1.24 (0.05)	.87**
Child's Hygiene → Clothes, child	0.94 (0.04)	.75**
Cleanliness related to animals → Animal feces	1.00	.65 [na]
Cleanliness related to animals → Animal cook	0.94 (0.28)	.47*
Cleanliness of the latrine → Latrine	1.00	.79 [na]
Hygiene of the household → Garbage	1.00	.75 [na]
Hygiene of the household → Floor	0.96 (0.10)	.71**
Commitment → Commitment latrine to cleaning	1.00	.46**
Commitment → Commitment to handwashing	1.24 (0.30)	.42 [na]
Structural Model		
General hygiene practice → Cleanliness of the latrine	0.27 (0.03)	.47**
General hygiene practice → Cleanliness related to animals	0.16 (0.03)	.34**
General hygiene practice → Hygiene of the household	0.38 (0.04)	.55**
General hygiene practice → Primary caregiver's hygiene	0.38 (0.03)	.73**
General hygiene practice → Cleanliness of water containers	0.33 (0.03)	.63**
General hygiene practice → Child's Hygiene	0.34 (0.03)	.55**
Covariance General hygiene practice and Commitment	0.20 (0.04)	.52**
Control: household wealth		
Control (household wealth) → Latrine	0.10 (0.01)	.28**
Control (household wealth) → Animal cook	0.01 (0.02)	.01
Control (household wealth) → Floor	0.08 (0.02)	.18**
Control (household wealth) → Animal feces	-0.01 (0.01)	-.02
Control (household wealth) → Water, covered	0.10 (0.02)	.20**
Control (household wealth) → Container, outside	0.06 (0.01)	.18**
Control (household wealth) → Container, inside	0.06 (0.01)	.19**
Control (household wealth) → Nails, mother	0.08 (0.01)	.20**
Control (household wealth) → Hands, mother	0.07 (0.02)	.16**
Control (household wealth) → Clothes, mother	0.09 (0.01)	.22**
Control (household wealth) → Nails, child	0.04 (0.01)	.10*
Control (household wealth) → Hands, child	0.06 (0.02)	.13**
Control (household wealth) → Clothes, child	0.06 (0.01)	.15**
Control (household wealth) → Garbage	0.06 (0.02)	.13*
Control (household wealth) → Commitment to latrine cleaning	0.11 (0.02)	.26*
Control (household wealth) → Commitment to handwashing	0.15 (0.02)	.26**

Note: Standard errors are in parentheses; $\chi^2(94, N = 761) = 340$; $p < .001$; CFI = . 93; RMSEA = .051.

* $p < .05$. ** $p > .001$

Table A6. Parameter estimates for the structural equation model „General hygiene practice: Relationship with Child Health“

Parameter Estimate	Unstandardized		Standardized
Measurement Model Estimates			
Cleanliness of water containers → Water, covered	0.77	(0.14)	.42**
Cleanliness of water containers → Container, outside	0.96	(0.09)	.72**
Cleanliness of water containers → Container, inside	1.00		.79 [na]
Primary caregiver's hygiene → Nails, mother	0.92	(0.07)	.61**
Primary caregiver's hygiene → Hands, mother	1.35	(0.09)	.77**
Primary caregiver's hygiene → Clothes, mother	1.00		.65 [na]
Child's Hygiene → Nails, child	1.00		.79 [na]
Child's Hygiene → Hands, child	1.23	(0.05)	.87**
Child's Hygiene → Clothes, child	0.94	(0.04)	.75**
Cleanliness related to animals → Animal feces	1.00		.65 [na]
Cleanliness related to animals → Animal cook	0.93	(0.26)	.47*
Cleanliness of the latrine → Latrine	1.00		.79 [na]
Hygiene of the household → Garbage	1.00		.74 [na]
Hygiene of the household → Floor	1.00	(0.10)	.72**
Child's health → Eyes discharge	0.60	(0.12)	.54**
Child's health → Nose discharge	1.00		.61 [na]
Structural Model			
General hygiene practice → Cleanliness of the latrine	0.24	(0.03)	.42**
General hygiene practice → Cleanliness related to animals	0.17	(0.03)	.36**
General hygiene practice → Hygiene of the household	0.39	(0.04)	.57**
General hygiene practice → Primary caregiver's hygiene	0.38	(0.03)	.73**
General hygiene practice → Cleanliness of water containers	0.30	(0.03)	.55**
General hygiene practice → Child's Hygiene	0.37	(0.03)	.60**
Covariance General hygiene practice and Child's health	0.23	(0.04)	.46**
Control: household wealth			
Control (household wealth) → Latrine	0.10	(0.01)	.28**
Control (household wealth) → Animal cook	0.01	(0.02)	.01
Control (household wealth) → Floor	0.08	(0.02)	.18**
Control (household wealth) → Animal feces	-0.01	(0.01)	-.02
Control (household wealth) → Water, covered	0.10	(0.02)	.20**
Control (household wealth) → Container, outside	0.06	(0.01)	.18**
Control (household wealth) → Container, inside	0.06	(0.01)	.19**
Control (household wealth) → Nails, mother	0.08	(0.01)	.20**
Control (household wealth) → Hands, mother	0.07	(0.02)	.16**
Control (household wealth) → Clothes, mother	0.09	(0.01)	.22**
Control (household wealth) → Nails, child	0.04	(0.01)	.10*
Control (household wealth) → Hands, child	0.06	(0.02)	.13**
Control (household wealth) → Clothes, child	0.06	(0.01)	.15**
Control (household wealth) → Garbage	0.06	(0.02)	.13*
Control (household wealth) → Nose discharge	0.00	(0.02)	.01
Control (household wealth) → Eyes discharge	0.00	(0.01)	.01

Note: Standard errors are in parentheses; $\chi^2(94, N = 761) = 300$; $p < .001$; CFI = . 94; RMSEA = .046.

* $p < .05$. ** $p > .001$

Table A7. Intercorrelations for the spot-checks

Hygiene domain	Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Child's hygiene	1. Nails, Child	—													
	2. Hands, Child	.70**	—												
	3. Clothes, Child	.61**	.68**	—											
Primary caregiver's hygiene	4. Nails, Mother	.38**	.30**	.30**	—										
	5. Hands, Mother	.25**	.39**	.29**	.50**	—									
	6. Clothes, Mother	.25**	.40**	.46**	.40**	.55**	—								
Cleanliness of water containers	7. Water, covered	.06	.11**	.17**	.10**	.14**	.23**	—							
	8. Container, outside	.21**	.21**	.29**	.25**	.23**	.32**	.28**	—						
	9. Container, inside	.05	.190**	.22**	.15**	.29**	.35**	.40**	.47**	—					
Cleanliness related to animals	10. Animal feces	.04	.05	.09*	.03	.06	.11**	.02	.10**	.08*	—				
	11. Animal cook	.10**	.07*	.11**	.12**	.01	.07*	.05	.08*	.01	.30**	—			
Hygiene of the household	12. Garbage	.17**	.21**	.22**	.16**	.21**	.26**	.15**	.22**	.22**	.27**	.15**	—		
	13. Floor	.19**	.20**	.2**	.22**	.24**	.24**	.21**	.22**	.16**	.22**	.15**	.56**	—	
Cleanliness of the latrine	14. Latrine	.11**	.12**	.17**	.19**	.18**	.24**	.11**	.23**	.29**	.10*	.09*	.22**	.23**	—

* p < .05. ** p > .001